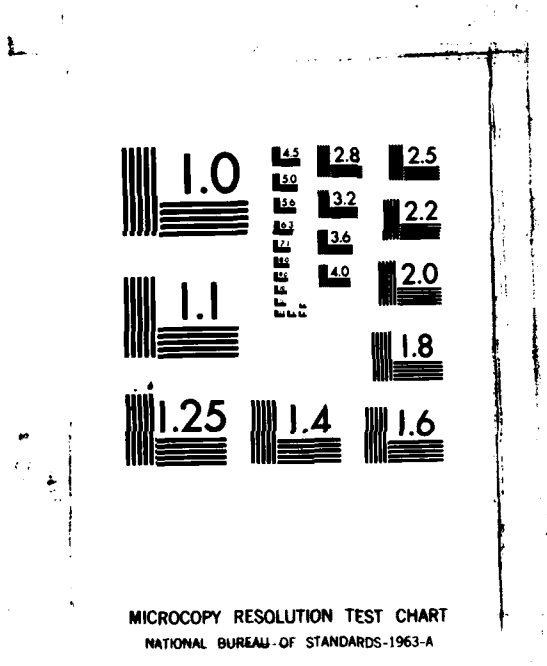
AD-A140 826 ONR (OFFICE OF NAVAL RESEARCH) FAR EAST SCIENTIFIC BULLETIN VOLUME 9 NUMB.. (U) OFFICE OF NAVAL RESEARCH LIAISON OFFICE FAR EAST APO SAN FRAN.. 1/2

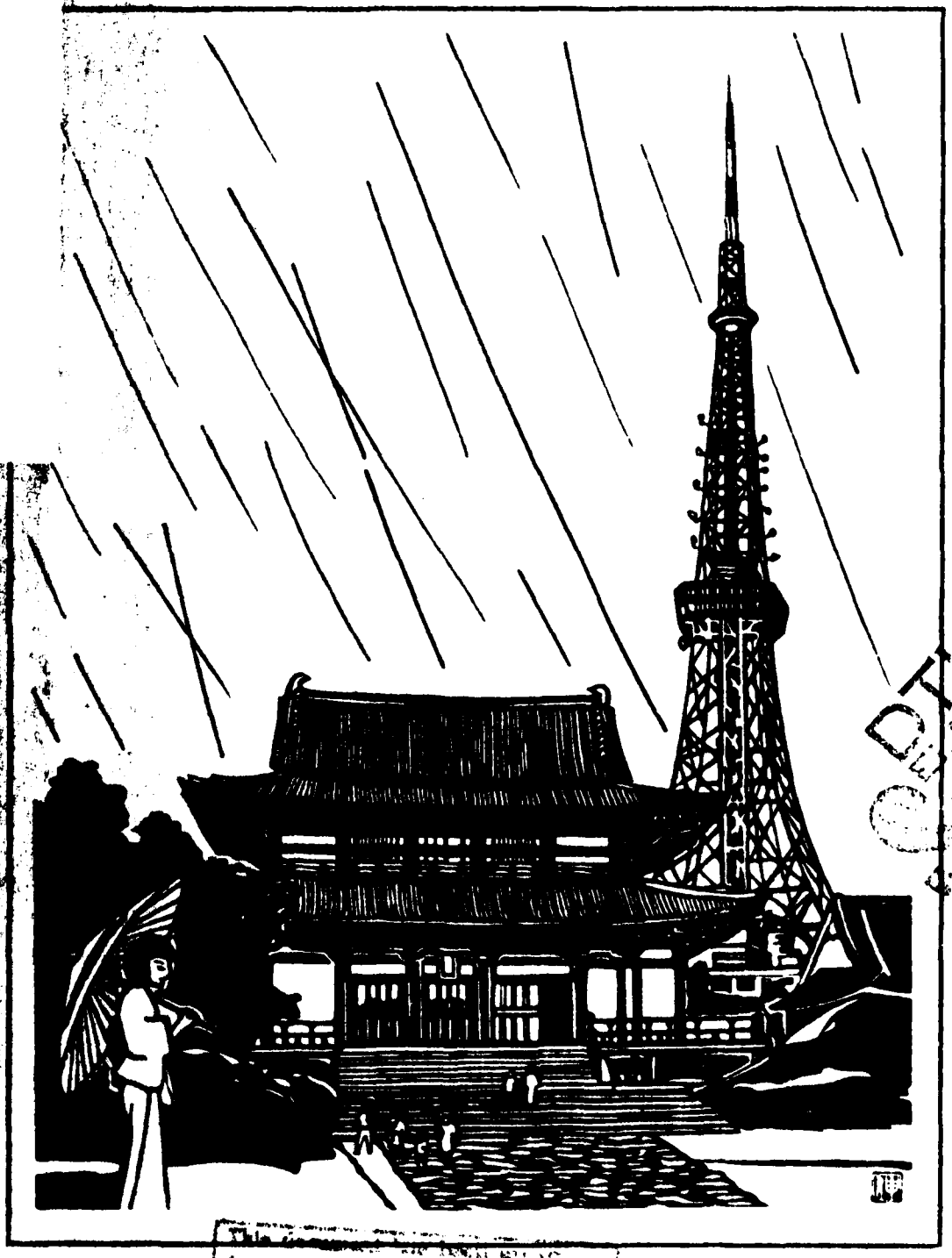
UNCLASSIFIED S YAMAMOTO ET AL. MAR 84 F/G 5/1 NL



...Y TO MARCH 1984 VOL. 9, NO.1

SCIENTIFIC BULLETIN

DEPARTMENT OF THE NAVY OFFICE OF NAVAL RESEARCH FAR EAST



NAVSO P-3580

12

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: ONRFE Vol 9, No 1 — 2. GOVT ACCESSION NO.: AD-A140 826	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): ONR FAR EAST SCIENTIFIC BULLETIN	5. TYPE OF REPORT & PERIOD COVERED
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Sachio Yamamoto, Director Mary Lou Moore, Assistant Editor	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Office of Naval Research Liaison Office, Far East APO San Francisco 96503	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE: January-March 1984
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)	15. SECURITY CLASS. (of this report): UNCLASSIFIED
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Fracture mechanics	Metallurgy
Beijing	Cryogenics
Subcritical crack growth	Metallography
Fracture theory	Materials research
Experimental fracture mechanics	China

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a quarterly publication presenting articles covering recent developments in Far Eastern (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Far East,

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

S/N 0102-LF-014-6601

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

19. Key Words (continued)

Supercomputers
Japan
Fujitsu
Hitachi
NEC
Applications
National Defense Academy
Engineering
Education
Yokosuka
Self-defense Forces
Computer science
Coke
Carbon
Graphite
Carbon fibers
Composites
Intercalation
Mesophase
Solid state physics
Superconductivity
Synchrotron radiation
Ultrahigh pressure techniques
High pressure science
Adsorbents
Elution
Uranium recovery concepts
Noopsychosomatic medicine
Logotherapy
Morita therapy
Japanese brain
Left hemisphere
Right hemisphere
Tsunoda method
Crickets
Doping
Immunomodulating drugs
Thymic hormones
Oriental medicine
Gingseng
Waken Yaku
Advanced displays
Human factors
Computers
Cognitive factors
Display research
Psychophysics
Gustation
Mouth sensitivity
Osaka Dental School
Discrimination performance
Cold environments
Low temperature climate research
Snow pack
Sea ice
Frost heaving
Snow melt
Chemical sensors
Semiconductor gas sensors
Biosensors
New methods
Japan
Uranium
Seawater
Powder metallurgy
Korea
Ferrite production
Tungsten
Neurosciences
Excitable membranes
Physiological sciences
Australia
Bulk crystal growth
Epitaxial crystal growth
GaAs
Neuroendocrine mechanisms
Kyoto
Sapporo
Herbs
Optoelectronic integrated circuits

20. Abstract (continued)

with certain reports being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

CONTRIBUTORS

Frederick R. Best received his Ph.D in nuclear engineering from the Massachusetts Institute of Technology where he began his work on uranium from seawater in 1978. Interphase transport phenomena are his areas of interest. He is presently an assistant professor of nuclear engineering at Texas A&M University and a reserve LCDR with the ONR/NRL 410 unit in Houston, Texas.

Nicholas A. Bond, Jr. is an engineering psychologist on leave from California State University at Sacramento and currently is a liaison scientist on the staff of ONR Far East. Dr. Bond's main interests are in man-machine interface, decision aiding, and the maintenance of complex systems by humans. Dr. Bond recently completed an assignment at ONR London. He is a fellow of the American Psychological Association.

P. F. Iampietro, a physiologist, is currently on the scientific staff of the Air Force Office of Scientific Research Far East. Previously he directed the Air Force basic research program in the life sciences. His scientific interests include environmental physiology and a more recent interest in membrane phenomena. Dr. Iampietro is a member of the American Physiological Society.

Sung M. Lee is professor of physics and also Director of the Keweenaw Research Center of the Michigan Technological University in Houghton, Michigan. Dr. Lee received his Ph.D from Ohio State University in 1965. Dr. Lee was a NATO Senior Fellow in 1974 and his research interests include infrared optics, acoustics, and applied physics.

George E. Lindamood is a liaison scientist with ONR Far East. His interests include computer architecture, computer networking, computer performance, evaluation, office automation, and the social implications of computers.

Jeannine A. Majde received her B.S. degree in zoology from the University of Chicago in 1964 and her Ph.D. degree in microbiology from Notre Dame University in 1970. Dr. Majde is a scientific officer with the Office of Naval Research in the biological sciences. Dr. Majde's research interests include immunopathology of chronic viral diseases, role of occult viruses in autoiummune diseases, cellular immunity, chemotheraphy of viral infections and immunopharmacology. Dr. Majde is a member of the American Society of Microbiology.

Harry I. McHenry is a supervisory metallurgist with the National Bureau of Standards in Boulder, Colorado. He received his Ph.D. from Lehigh University in 1970. Dr. McHenry's principal duties are to conduct fracture mechanics research relating to the structural safety of ships, pipelines, offshore structures, and cryogenic systems. Prior to going to NBS in 1974, Dr. McHenry served as a project structures engineer for General Dynamics Corporation (1963-1974), where he applied fracture mechanics to the design and evaluation of aircraft structures.

Paul Naitoh is currently with the Naval Health Research Center, San Diego. His research interests are primarily concerned with psychophysiological and biocemical problems of sleep, sleep deprivation, and alcoholism. One of his previous investigations included statistical analyses of multivariate time-series describing various biological rhythms, from oscillatory electrical activities of the brain to circadian fluctuations in bodily functions and task performances. In 1974 he was an invited research associate of the Centre National de la Research Scientifique of the Centre d'Etudes Bioclimatiques in Strasbourg, France.

Yoon Soo Park is currently a senior scientist with the Air Force Office of Scientific Research Far East. Prior to his assignment in Japan in September 1983, Dr. Park was a task manager and research physicist at the Avionics Laboratory, Air Force Wright Aeronautical Laboratories. His research interests lie in the areas of electronic materials and devices. Dr. Park is a fellow of the American Physical Society and a senior member of IEEE.

Earl F. Skelton is head of the Phase Transformation Section at the Naval Research Laboratory, a professor in the School of Engineering, George Washington University, and a research associate at the University of Hawaii. He has been actively engaged in high pressure research for more than 15 years and spent the past four years developing a facility at Stanford University for ultrarapid structural studies under elevated pressure conditions using synchrotron radiation.

Jack L. White is a carbon scientist working in the Materials Sciences Laboratory of the Aerospace Corporation in Los Angeles, California. His current research interests are directed to understanding the properties and mechanisms of formation of such materials as carbon fibers and carbon-fiber-reinforced composites. His experience includes university teaching and consulting to firms in petroleum products development and nuclear power. He has recently been selected by the American Carbon Society as the George D. Graffin Lecturer in Carbon Science and Engineering for 1984.

Sachio Yamamoto, a marine chemist, is currently the Director of ONR Far East. He is on leave from his position as head of the Marine Sciences Division at the Naval Ocean Systems Center in San Diego where, since 1969, he has served as a research chemist. Dr. Yamamoto received his Ph.D. in physical chemistry from Iowa State University in 1959, and his research interests are primarily in environmental sciences, trace metal analysis, gas solubility, and x-ray fluorescence analysis. Dr. Yamamoto is a member of the American Chemical Society.

Duk Nong Yoon is a professor in the Department of Materials Science and Engineering at the Korea Advanced Institute of Science and Technology (KAIST) in Seoul, Korea. Dr. Yoon received a B.S. degree in physics from the Massachusetts Institute of Technology and a Ph.D. degree in materials science from Harvard University. Dr. Yoon's research interests include powder metallurgy and materials processing. Dr. Yoon has also been visiting scientist at the Max Planck Institute für Metallforschung, West Germany.

CONTENTS

Cover: This woodcut depicts the essence of the Japanese culture which combines the traditional with the modern. The temple, Zojoji, located at Shiba-Koen in Central Tokyo, is juxtaposed against Tokyo Tower which is the tallest man-made structure in Tokyo. This woodblock print is presented here through the courtesy of its artist, Nobuyuki Goto and the Ohfusha Publishing Company which published copies of the artist's prints in a book collection entitled *Furusato Yumegeshiki - Shin-Tokyo Hyakkei*.

ICF INTERNATIONAL SYMPOSIUM ON FRACTURE MECHANICS: BEIJING, PEOPLE'S REPUBLIC OF CHINA

Harry I. McHenry

INTRODUCTION

The ICF International Symposium on Fracture Mechanics was held in Beijing, People's Republic of China, from 22-25 November 1983. The symposium was conducted under the auspices of the International Congress on Fracture (ICF) and was sponsored by the Chinese Society of Theoretical and Applied Mechanics and the Chinese Society of Aeronautics and Astronautics. The symposium agenda started with registration and a visit to the Beijing Institute of Aeronautics and Astronautics on Monday, 21 November. The technical sessions started on Tuesday with a full day of invited lectures, 16 lectures in two parallel sessions. On Wednesday and Thursday, 102 contributed papers were presented in four parallel sessions. The attendance was 158 scientists, including 114 Chinese and 44 delegates from ten other countries. The 44 foreign participants included 12 from the U.S.A., 15 from Japan, and 16 from Europe.

The proceedings of the symposium, consisting of 132 papers, were published and distributed during registration. A review of the proceedings indicates that the papers fall in three general categories:

- theoretical and analytical fracture mechanics (42 papers, 30 from China),
- experimental and applied fracture mechanics (43 papers, 27 from China),
- subcritical crack growth (46 papers, 19 from China).

In this report, the technical papers are discussed under these three headings. The key issues are identified with emphasis on the invited papers and the papers from China. The tour of the Beijing Institute of Aeronautics and Astronautics is briefly described.

THEORETICAL AND ANALYTICAL FRACTURE MECHANICS

The Office of Naval Research was well represented with two of the four invited lectures in this topical area covering ONR-sponsored research. Professor S. N. Atluri of the Georgia Institute of Technology presented, "Computational and Theoretical Studies on Dynamic Fracture Mechanics and Three-dimensional Crack Problems." This paper summarized recent work that has been previously published (1980-1983) in 21 papers by this remarkably productive researcher and his coinvestigator, Dr. T. Nishioka. A moving singular element procedure is described for elastodynamic problems of fast crack propagation in finite bodies. The accuracy of the analysis was verified by comparing the results with analytic solutions for infinite domain cases. The method was used to study the fast fracture behavior of dynamic tear (DT) test specimens of 4340 steel, and used as the basis for proposing a method for determining dynamic stress intensity factors directly from crack mouth opening displacements in a DT test. Path independent integrals were derived to characterize the severity of the stress field at the tip of an elastodynamically propagating crack. Professor Atluri's paper also describes research on three-dimensional crack problems. The alternating method of Shah and Kobayashi (*Engr. Fract. Mech.*, 1971) has been extended by deriving a complete general analytical solution for an elliptical crack embedded in an infinite elastic medium and subject to arbitrary tractions. The new alternating method is used in conjuction with finite

element analysis to enable the rapid (with respect to computer time) and accurate calculation of stress intensity factors for flaws in structures. The method has been used to solve a variety of problems including corner cracks, surface flaws and embedded flaws in finite-thickness plates, bars, and lugs.

The other invited lecture covering ONR-sponsored research was a paper entitled, "Plastic Deformation and Hardening Characteristics in Three-dimensional Fracture Specimens," by E. T. Moyer, Jr. and H. Liebowitz. In the paper, the finite element formulation for general 3-D elastic bodies is presented for the case of small strain plasticity. The finite element analysis program based on this formulation is used to compute the crack tip yield contours for hardening models: isotropic, kinematic, and mixed. The von Mises yield criterion was used in all three models. The size and shape of the plastic zones calculated by each hardening model were similar. No conclusions were drawn. The oral presentation was a tutorial on how to develop a code for a VAX-type computer based on the formulation presented in the paper. Not being competent in that area, I found it dreadful, but the Chinese members of the audience were all ears, and there were numerous detailed questions following the presentation.

In the area of fracture theory, several ideas that were new to this fracture mechanics audience were introduced in a lively session in which Dr. I. H. Lin of the National Bureau of Standards (NBS) presented his paper, "Dislocation-shielding Analysis of a Blunt-notched Brittle Crack Embedded in a Ductile Material" and a paper by his NBS colleague, Dr. R. M. Thomson entitled, "Dislocation Shielding of Cracks and the Fracture Criterion." Dr. Lin was given 40 minutes for the "double-paper" and it was followed by 40 minutes of vigorous discussion in the best traditions of a technical meeting. Three ideas were presented that had been introduced in previous papers but are quite new. First, an elastic enclave exists between the crack tip and the plastic zone (Thomson, *J. Matls. Sci*, 1978, and Weertman *Acta Met*, 1978); dislocations that would be in this zone are either repelled into the plastic zone or absorbed by the crack tip. Second, the crack tip is shielded by dislocations which reduce the local crack-tip stress intensity below that computed based on continuum theory (Majumdai and Burns, *Acta Met*, 1981, Thomson and Sinclair, *Acta Met*, 1982), i.e., the dislocations surrounding the crack tip exert a closure force on the crack. Third, dislocations are emitted from the crack (Rice and Thomson, *Phil. Mag.*, 1974) and emission continues until the resulting dislocation pileup reduces the local stress intensity below that required for emission (Lin and Thomson, *Scripta Met*, 1983). Similar topics were discussed in a presentation by Professor J.C.M. Li of the University of Rochester entitled, "Dynamic Emission of Dislocations from a Crack Tip: A Computer Simulation," by R. H. Zhao, S. H. Dai, and J.C.M. Li. The ideas of dislocation emission, dislocation shielding, and elastic enclave offer insight into experimental observations that are not consistent with continuum theory, e.g., an atomically sharp crack and the existence of a dislocation free zone at the crack tip. It was a pleasure to hear them expressed to a fracture mechanics audience. We are likely to hear more about them at future meetings.

- Chinese Papers on Theory and Analysis

Of the 42 papers on theory and analysis, 30 were by Chinese authors. One of these papers was an invited presentation by Hwang Keh-chih and Liu Chuntu entitled, "Some Theoretical Works on Fracture Mechanics in China." This paper was limited to analytical studies at the Institute of Mechanics, Qinghua (Tsinghua) University, and the Harbin Shipbuilding Engineering Institute. The paper reviewed 41 previously published papers including some that were published originally in Chinese and then again at this conference. Emphasis was on the works of He Ming-yuan (six papers) who studied at

Harvard University under Professor J. W. Hutchinson, Gao Hua, (13 papers) who studied at Northwestern University under Professor S. Nemat-Nasser, and the works of the authors (nine papers). Of the 41 papers, 18 were on the stress of analysis of cracked bodies, eight were on fracture criteria (there appears to be a fascination with mixed mode fracture), and 15 were on singularity fields during crack growth (stable crack growth and dynamic fracture). The contributed papers covered topics that were similar to those covered in the invited paper. Numerical analysis, especially the finite element method, is being widely used to solve linear elastic and elastic-plastic fracture problems. It appears from these papers that selected Chinese researchers have achieved a high level of sophistication in analytical fracture mechanics. As might be expected, the papers are rooted in previous studies by Western investigators. New directions and approaches were not evident. The problem selection appeared to be quite academic; no association with the industrialization goals of China was apparent. But, this is the nature of papers on theory and analysis that are suitable for international symposia.

EXPERIMENTAL AND APPLIED FRACTURE MECHANICS

There were six invited papers in experimental and applied fracture mechanics. Topics covered were:

- brittle fracture under combined modes,
- dynamic fracture,
- fracture toughness testing,
- rock mechanics,
- design methods, and
- applications in China.

These papers address some of the leading issues in fracture mechanics, and thus, each will be briefly discussed with reference to contributed papers on related subjects.

Professor Yukio Ueda of Osaka University presented an invited lecture entitled, "Characteristics of Brittle Facture Under General Combined Modes." The work was conducted from 1975 to 1980 by a group that included Drs. K. Ikeda and M. Aoki of Kobe Steel and Professor T. Yao of Hiroshima University. A more complete summary of the work appears in *Engineering Fracture Mechanics, 18* (6), 1983. The brittle fracture initiation characteristics under general combinations of Modes I, II, and III were investigated both theoretically and experimentally. For the linear elastic case, the stress parallel to the notch does not affect the direction of initial crack propagation or the fracture strength; the fracture criterion based on the maximum strain energy release rate, G, is most suitable. Upon small-scale yielding, the fracture strength is higher than predicted by G and increases with an increase in Mode II deformation. For large-scale yielding, the stress parallel to the notch influences the size and shape of the plastic zone, and consequently, the crack opening displacment, (COD). A combined mode (I and II) COD was measured. Brittle fracture initiates perpendicular to the COD vector, but the measured strength is higher than predicted by the COD criterion and increases with increased Mode II deformation. The beneficial effect of Mode II deformation is attributed to a reduction in strain energy at the crack tip region, which is dissipated as plastic work due to Mode II deformation. This is the most complete study of combined mode fracture known to the author. The first measurements of a combined mode COD and the systematic variation of plasticity make this an important contribution to the technical literature. Several contributed papers were presented on theoretical, analytical, and experimental studies of mixed mode fracture. Experimental papers included photoelastic studies of mixed mode stress intensity factors and crack tip plasticity, ar[illegible] an ex[illegible]rimental evaluation of slant cracks in pressure vessels.

Dynamic fracture was addressed in an invited lecture by G. Pluvinage and V. Garnier (University of Metz, France) entitled, "Influence of High Loading Rate on the Fracture Toughness of Steels." The fracture toughness of three steels (400, 650, and 1315 MPa yield strengths) were determined for strain rates ranging from 10^{-3} to 10^{6}/s. The highest rates were measured with a split Hopkinson pressure bar apparatus. The results are consistent with previously published studies (e.g., Barsom, 1976). There were two contributed papers on the measurement of dynamic fracture toughness; Professor J. A. Joyce of the United States Naval Academy and E.M. Hackett of the David Taylor Naval Ship Research and Development Center used the key curve method to measure the dynamic J resistance curve in a drop weight dynamic tear (DT) test. The approach has promise for obtaining more useful information from a DT test, but the particular experimental program discussed was limited to the uninteresting case of upper shelf (ductile) behavior. The second paper described an instrumented Charpy-type machine developed in China by Lin, *et al.*, at the Lanzhou Railway Institute.

The Japanese standard method for conducting a J_{IC} fracture toughness test was described in an invited paper by H. Miyamoto, H. Kobayashi, and N. Ohtsuka. The standard, entitled, "Standard Method of Test for Elastic-plastic Fracture Toughness J_{IC}," was published by the Japan Society of Mechanical Engineers (JSME) in 1981 under the designation of JSME S001-1981. The method was compared to the ASTM standard on J_{IC} testing, ASTM E813-81, which was also published in 1981. The concept and intention of both test methods are the same, but there are several significant differences in the experimental procedures. Crack extension (Δa) is measured at mid-thickness, rather than through the thickness. The blunting line is measured experimentally rather than calculated. Stretch zone width (SZW) measurements can be used instead of the multiple specimen R-curve method. Electrical potential, ultrasonic, and acoustic emission techniques can be used for single specimen testing, but the ASTM unloading compliance technique is not allowed. Other minor differences exist relative to thickness requirements, range of crack extension data used to determine the R-curve, and the number of specimens required. In related papers, H. Kobayashi (Tokyo Institute of Technology) and T. Mura (Northwestern University) discuss the blunting line in the J_{IC} test and Guo *et al.* (Beijing Polytechnic University) discuss J_{IC} testing at low temperatures using both the JSME and ASTM procedures.

Dr. E. P. Chen of Sandia National Laboratories presented an invited paper entitled, "Fracture Mechanics Applications in Rock Mechanics Problems." The strain rate dependent fracture of rocks with existing flaw distributions is discussed for the cases of high energy gas fracturing and oil shale blasting. There were six contributed papers on fracture of nonmetallic materials; five of these were on composite materials.

Professor C. E. Turner of Imperial College, U.K. presented an invited paper entitled, "A Comparison of Three Design Methods for Estimating Values of J and COD Applied to a Crack with Yielded Ligament." The three methods compared are the COD design curve (PD 6493, British Standards Institution, 1980), the R6 method (CEGB, England), and the EnJ method (Turner, ASTM STP 803, 1983). Similar results are obtained if similar safety factors are used. In a related paper, A. Bakker (Delft University of Technology) compared experimental results and numerical analysis predictions for the case of a corner crack in a plate under elastic-plastic conditions. The initiation and growth of the crack (experimentally observed) was described in terms of local J-values computed numerically, and the results (J vs. Δa) compare well with those obtained in a single edge notch bend test. K. H. Schwalbe (GKSS, Geesthacht) presented a simple model estimating the J-integral for a center cracked panel in tension. Comparison with experimental values of three different materials demonstrated good coincidence.

- Chinese Papers on Applications

Mr. He Qing-zhi (Beijing Institute of Aeronautics and Astronautics) presented an invited paper entitled, "Some Applications of Fracture Mechanics in China." Fracture mechanics was introduced into China in the late 1960s and is used in the fail-safe design of new structures and in the safety assessment of "older" ones. Several examples of fracture analysis and safety assessments are given including rotor forgings for a 300 MW steam turbine, ladle trunions, aircraft structures, pressure vessels, and railway locomotive shafts. The damage tolerance design philosophy is claimed to have been applied to aircraft structures in the late '60s, about when the United States Air Force (USAF) was first using this approach. The Y10 transport aircraft was designed for damage tolerance. Life extension plans were developed for landing gear on fighter aircraft and fuselage structures on cargo aircraft. Fighter aircraft designed prior to the use of fracture mechanics were assessed to determine remaining operational life on the basis of test results obtained using service loads spectra and crack growth models (with retardation). Probabilistic fracture mechanics was used to evaluate the service life distribution of ladle trunions. Contributed papers were presented on applications to hoisting devices, pressure vessels, aircraft structures, turbines, weldments, and hub-arms of helicopters.

SUBCRITICAL CRACK GROWTH

The 46 papers in this category include papers on fatigue, creep, stress corrosion cracking, and hydrogen cracking. Two invited papers were given on fatigue crack propagation, two on the fatigue-creep interaction, and one on creep crack growth.

Professor Kunihiro Iida of Tokyo University, presented an invited paper entitled, "Shapes and Coalescence of Surface Fatigue Cracks." The paper is based on six years of research conducted by several Japanese laboratories to examine some points in question about the fracture mechanics evaluation procedure given in Section XI of the ASME Boiler and Pressure Vessel Code. The paper was limited to two of the topics studied: aspect ratio expressions for surface fatigue cracks and coalescence conditions for multiple surface fatigue cracks. Simple analytical expressions, suitable for use in crack growth computer programs, are presented for the aspect ratio of a propagating fatigue crack. A method of estimating the crack propagation life for the case of aligned coplanar flaws which grow together is proposed. The condition for coalescence of parallel (noncoplaner) surface cracks are defined. The variation of flaw shape as the crack propagates was addressed in two contributed papers by Sun and Chen (Southwestern Jiaotong University) who presented a shape function for a surface crack subject to fatigue cycling under combined tension and bending. In a related paper, Dover (University College, London) describes an ac field measurement technique for monitoring fatigue crack shape during fatigue cycling.

Professor H. W. Liu of Syracuse University presented an invited paper entitled, "Near Threshold Fatigue Crack Growth in Steels: An Analysis Based on Crack Tip Plastic Deformation," coauthored by Dai Liu of the Beijing Materials Handling Institute. This paper attempts to relate fatigue crack growth to microstructures. Two models for the fatigue threshold are proposed and a semiempirical theory for fatigue crack growth is constructed and found to agree with data for several steels. Two contributed papers from China also discussed the fatigue threshold, with emphasis on the behavior of small cracks.

Three invited papers dealt with creep or the creep fatigue interaction. Dr. H. Riedel of the Max Planck Institute for Eisenforschung (Dusseldorf) presented one

entitled, "The Use and Limitations of C* in Creep Crack Growth Testing." The theoretical basis for C* testing was described and the observed dependences of the crack growth rate on C* were explained on the basis of a critical strain criterion for crack growth. Limitations on C* are discussed, but in general, the presentation strongly advocated the use of C* for creep crack growth studies. Professor D.M.R. Taplin (Trinity College, Ireland) presented, "Fatigue Cavitation at High Temperature," which reviewed the intergranular damage accumulation process that occurs during fatigue at high temperatures, i.e., cavity nucleation, growth and linkage at grain boundaries. Professor Takeo Yokobori (Tohoku University) presented, "Hold Time Effects on High Temperature Crack Growth Rate in Creep, Fatigue and the Creep-fatigue Interaction in Stainless Steel." An empirical formula for crack growth rate under creep fatigue conditions is given as a function of hold time.

About 40 contributed papers were presented on subcritical crack growth. Topics of principal interest were the initiation and fatigue crack growth of small cracks (seven papers), fatigue under variable amplitude loading (seven papers), and crack growth at elevated temperatures (seven papers). Surprisingly little attention was given to corrosion enhanced fatigue and stress corrosion cracking (three papers).

There were three papers on subcritical crack growth of particular interest to the author. Dr. Yoshio Kitsunai of the National Research Institute of Industrial Safety (Japan) presented a paper that very clearly demonstrated the influence of residual stresses on fatigue crack growth. When conventional procedures are used, crack growth rates are often substantially slower in welds than in base metals. In addition, welded specimens often exhibit an extremely high threshold, the stress intensity below which crack growth does not occur. Both of these anomalies were clearly explained by accounting for crack closure and reevaluating the data in terms of the effective stress intensity range, ΔK_{eff}. The closure stress intensity was measured with a strain gauge mounted on the back surface of the specimen. When the crack growth rates are plotted versus ΔK_{eff}, the data for base metals and welds fall in the same scatter band. Thus, the influence of residual stress is due to crack closure.

Professor M. Chrzanowski of Technical University (Poland), the only conference participant from Eastern Europe, presented a paper on creep crack growth in damaged material. The concepts of continuous damage mechanics (CDM) were used instead of the dominant crack fracture mechanics approach. This formulation accounts for the main features of creep fracture, i.e., voids initiate at grain boundaries and only in the final stages of creep do they link into cracks and cause fracture. Thus, for the assessment of structural safety, the long period damage phase is more important than the brief crack growth phase. The proposed model was not critically evaluated by comparison with experimental results, but the concept deserves more attention by the fracture mechanics community.

A paper entitled, "Quantitative Investigation of Initiation and Early Growth Process of Fatigue Microcracks in Low Carbon Steel," was presented by Professor Y. Ochi (coauthored by S. Sasaki) of Electrocommunications University (Japan). In this study, high cycle fatigue tests were conducted on smooth bar specimens. The formation of fatigue slip bands, and the initiation and propagation of microcracks were quantitatively characterized from various observations of the surface, the fracture surface, and specimen cross sections. The results provide the quantitative information needed for the statistical modeling of fatigue test results.

- Chinese Papers on Subcritical Crack Growth

In the first two categories of papers, fully two-thirds of the papers were contributed by China. In contrast, only 19 of 46 papers on subcritical crack growth were from China. A possible reason is that fatigue crack growth studies are commonly conducted in sophisticated servohydraulic test machines, often in conjuction with a computer. This type of equipment is probably not widely available in China.

Most of the Chinese papers in this category were studies of fatigue crack propagation, plus three on creep, one on hydrogen cracking, and one on stress corrosion cracking. The fatigue papers had remarkable diversity, including studies of peak overload effects, spectrum loading, the crack growth threshold for shallow cracks, creep fatigue interaction, mixed mode loading, and nonproportional loading. These papers plus the use of fatigue crack growth analysis in many of the applications papers suggest a broad awareness of the fracture mechanics approach to fatigue.

BEIJING INSTITUTE OF AERONAUTICS AND ASTRONAUTICS (BIAA)

The foreign participants at the conference were invited to visit the BIAA. We were given an overview presentation by Professor Shen Yuan, president of the institute, and a brochure describing the institute's activities. BIAA is an educational institution with research capabilities. There are 1600 staff members, including 400 professors and associate professors, 4000 undergraduates, and 400 graduate students. Following the overview, we were given a tour in which we briefly (about 20 minutes per department) visited four departments.

The Materials Science and Engineering Department was shown to us by Professor Chen. We visited the scanning electron microscopy (SEM) laboratory, the optical microscopy laboratory, and the mechanical testing laboratory. These are all apparently educational laboratories because there was very little evidence of ongoing research. The equipment included an SEM made in China, two Zeiss metallographs, and several mechanical testing machines, including an Amsler (Swiss) vibraphone.

The engine test laboratory was shown to us by Profess Hsu. We visited the vibration laboratory, which was equipped with old shakers and vacuum tube instrumentation. The rotor test laboratory was used to conduct critical speed tests in a lathe-like apparatus. The photoelasticity laboratory was equipped with a laser (made in China) and was set up with an experiment to measure the stress profiles at the "Christmas tree" connection of turbine blades to the rotor. Photographs of photoelastic patterns were quite good, and apparently publishable research is being done in this area.

The thermal stress laboratory had the wing of a missile in a test rig. Mechanical loads simulating pressure on the wing were applied using a complex whiffle-tree arrangement. Thermal stress was superimposed with quartz heaters. It appeared to be a student laboratory, where the same experiment could be repeated by many classes.

The jet propulsion laboratory was shown to us by Professor Chu. This appeared to be a very active research laboratory. A wind tunnel with Mach 2.5 capability was built by the institute in 1959. The data acquisition system used punch tape. There were several ports for experiments and many models of aircraft and rockets. Professor Chu spoke with pride about the productivity of the laboratory, and judging from the beehive of activity, rightfully so.

CHINA'S INSTITUTE OF METAL RESEARCH

Harry I. McHenry

INTRODUCTION

The Institute of Metal Research (IMR) of Academia Sinica is one of the largest centers for materials science and engineering in the People's Republic of China. It is located in Shenyang, an industrial city in northern China with a population of about four million. The institute has 1200 employees, including an academic and technical staff of more than 600. There are nine professors, 43 associate professors, 13 senior engineers and 75 graduate students. The institute director is Professor C. H. Shih who was educated in the U. S., vintage 1950. He received an M.S. from the Missouri School of Mines, a Ph.D. from Notre Dame University and was a postdoctoral fellow at the Massuchusetts Institute of Technology (MIT).

The IMR was established in 1953 as a scientific center for the study of metallurgy. During the cultural revolution, it was assigned to the Ministry of Metallurgical Industries and emphasis shifted to technological support for industry; it remained in the Ministry from 1968-1976. In 1976, it was reassigned to the Academia Sinica. Due to China's recent modernization goals, the institute has retained an emphasis on applied research. Industrial support and technology transfer appears to be mainly to the nonferrous and high technology sectors of China's industry.

I visited the IMR from 28 November to 1 December 1983 at the invitation of the Academia Sinica in accordance with the science cooperation agreement between the U.S.A. and China. The purpose of my visit was to lecture on "Materials for Cryogenic Service." The lectures were presented to a class of thirty people; about half of the class were from the IMR and half were from ten other organizations throughout China. The lecture topics are given below:

- Day 1 Materials for Cryogenic Service - An Overview
- Day 2 Properties of Alloys at Low Temperatures
- Day 3 Fracture Mechanics
- Day 4 Mechanical Testing in Liquid Helium, and Comments on Research Needs for Cryogenic Materials

Lecturing in China is an interesting and rewarding experience, but it is not a particularly easy task. Each morning, I lectured from two to three hours, which sounds unreasonably long; but with an interpreter, only 60% efficiency is achieved. In the afternoon, there were technical discussions on the lecture topics and laboratory visits.

In this report, the research programs and capabilities of the institute are discussed. The report is organized in accordance with the organization of the institute as described in an English language brochure entitled, *Institute of Metals Research, Academia Sinica* (undated, approximately 1982). This report includes information from the brochure plus information and observations made during laboratory visits and numerous discussions.

Research at the institute is organized into three divisions, and the Department of Technological Development. Each division has eight to ten separate groups, each with a specific area of materials research. The three divisions are:

- metallography and metal physics,
- materials research,
- new technologies and processes.

METALLOGRAPHY AND METAL PHYSICS

The groups in this division conduct basic research in materials science, provide analytical services to the other groups, and do applied research in the areas of fatigue and fracture. The Corrosion, Oxidation, and Protection Group has recently been separated from the institute to form the nucleus of a new institute.

- Crystal Structure and Crystal Defects

This group is led by Professor Guo Ke-xin, a leading authority on high resolution microscopy and a member of the Academia Sinica. Professor Guo conducted research in Sweden for ten years prior to returning to China in the 1950s. The laboratory is equipped with a JEM 200CX electron microscope. Structural images at atomic resolution can be obtained. A high resolution image of the 9R long period structures (ABCBCACAB stacking) in the Ni_3 (TiV) alloy along the [010] orientation is used as an example in the brochure.

This group also conducts applied research in surface science. They are equipped with an Auger electron spectroscope and a low energy electron diffraction (AES-LEED) unit coupled in a common chamber for surface analysis, and a field ion microscope (FIM) atom probe. The AES-LEED was made by Riber (France) and has been at the institute for about 10 years. Currently, they are studying absorption/desorption of gases on metal surfaces with the aid of a heater in the vacuum chamber. Charpy-size (10 X 10 mm) specimens can be fractured in a chamber capable of cooling the specimen with liquid nitrogen to study grain boundary embrittlement, surface films, etc. The instrument was demonstrated by Y. N. Fan.

- Defects and Mechanical Properties of Metals

Professor Long Qi-wei, an authority on the dislocation modeling of crack tip processes, is the leader of this group. The laboratory is equipped with an accelerator for position annihilation studies, a Mössbauer spectroscope, and a computer-controlled torsion pendulum for internal friction studies.

- Physical Properties of Solids

This group is headed by Professor B. L. Chou, who recently returned from the University of Connecticut where he studied low temperature physics. The laboratory has equipment for measuring physical properties including thermal conductivity (a laser pulse device), thermal expansion, specific heat (autoadiabatic device), elastic modulus (ultrasonic) and radiative emissivity of metals. Basic research is done on lattice vibrations modeling of physical properties and microscopic dynamic processes of thermal expansion. Recent applied work has been related to superconductivity (a recurring topic at the institute) and thermoelectric power of intercalation compounds.

- Fatigue Fracture

The fatigue research laboratory is headed by Professor Zhang who was absent during my visit. The group includes Mr. S. J. Gao, who studied under Professor R. P. Wei at Lehigh University (1979-1981), and Mr. Wang Zhong Guang, who recently studied under Professor Campbell Laird at the University of Pennsylvania. The laboratory was shown to me by Mr. Y. P. Hsia and Mr. Gao. It is equipped with a 16-ton capacity Schenck (Germany) servohydraulic fatigue machine. The machine is equipped with a Programmatron (Swiss) for programmed load tests and a noise generator (Hewlett-Packard) for random load tests. Crack length measurements are made by the ac potential drop method (same procedure as R. P. Wei at Lehigh) using a constant current lock-in amplifier (Princeton Applied Research). The group has done basic research on the cyclic stress-strain behavior of FCC single crystals and Stage I fatigue in pure aluminum. Applied research projects include:

- corrosion fatigue crack growth,
- effects of metallurgical and environmental factors on the fatigue threshold,
- overload retardation,
- the creep fatigue interaction, and
- residual stress and surface treatment effects.

A separate laboratory was also engaged in fatigue and fracture studies. It was equipped with a fatigue machine similar to an Amsler vibraphore, but it was made in China, and a flywheel type dynamic test machine (East Germany). The fatigue machine is capable of very high frequencies (80-150 Hz) and is used for crack growth threshold studies on stainless steel and high strength steels. A dc potential drop technique is used for crack length measurements using China-made equipment. The dynamic test machine has a 2-ton force capacity at loading rates of 5-50 ms^{-1}. Precracked Charpy specimens are used. The laboratory also conducts fracture toughness tests on three-point bend specimens and stress corrosion cracking tests on tapered DCB specimens.

In addition to the research laboratories, there is a large mechanical test laboratory used for routine testing. It is equipped with about ten load frames for fatigue and tensile testing, two Charpy impact machines, about six eccentric load rotating fatigue machines, about six hardness testers and miscellaneous other equipment. None of the equipment was particularly new, none had noteworthy capabilities. The laboratory was shown to me by Mr. Hsu.

- Fractography and Failure Analysis

I visited two laboratories that I think are part of this group. One laboratory features a scanning electron microscope (Cambridge S4-10) purchased in 1974. It is equipped with an energy dispersion analyzer (EDAX) for chemical analysis, a high temperature stage (to 1100°C), a low temperature stage, and a chamber for viewing large specimens (100 x 100 mm). Specimens can be broken within the chamber (maximum force is 227 kg). The laboratory was shown to me by Mr. Su Shu-he. Photographs displayed in the laboratory showed progressive crack formation along MnS inclusions, shear nucleated cleavage cracking in titanium, hydrogen cracking in iron, mechanism of flake formation in steel, etc.

The other laboratory has a new (1982) electron microprobe made by Cameca (Camebax Micro) of France. It is equipped with an electromagnetic lense and has a resolution for x-ray analysis of 2-3 μ and can be used to detect elements down to atomic

number 5, boron. The computer software used for spectral analsysis is run by a Digital Equipment PDP 1103-L. The instrument was shown to me by Mrs. Xu Li-ying. It is a service instrument used by the institute for microanalysis.

- Rare Earth Transition Metal Intermetallic Compounds

This group was headed by Professor Zhuang Yu-zhi who is now deputy director of the IMR. Professor Zhuang was educated in England and is a member of Academia Sinica. The group does basic research on phase transformations and physical properties of compounds of rare earths and transistion elements. This work is part of an effort to develop rare-earth compounds with unique properties as part of the institute's goal to increase use of China's abundant supply of rare-earth metals.

- Physical Metallurgy of Welding

I visited two laboratories related to welding. The one with the weld cycle simulator is described here and the laser laboratory later. Mrs. Li Jing-li showed me the new (August 1983) Gleeble 1500 weld cycle simulator made by Duffers Associates (U.S.A.). This is the latest instrument for studying the heat-affected zone (HAZ) of welds. It is capable of heating metal specimens (10 X 10 X 100 mm is typical) in accordance with preprogrammed instructions in terms of the time temperature cycle. The machine is equipped with a differential thermal analyzer for transformation studies, a vacuum chamber, a quench facility capable of 10 °C/sec cooling rates, and an IBM personnal computer that serves as a terminal (a Texas Instruments computer is used for control). The unit is used for weld solidification and cracking studies, continuous cooling transformation diagrams, and structure/property studies.

MATERIALS RESEARCH

There are ten research groups in the Materials Research Division, each responsible for a particular class of materials. I only visited two of these groups, Cryogenic Steels and Amorphous and Liquid Metals. Information on the others is limited.

- Superalloys

This group was formerly headed by Professor Shih, the director of the IMR. It has a distinguished record of developing cast and wrought superalloys for use in jet engines. Professor Shih talked with pride of developing cast turbine disks with the perforations needed for cooling within two years of the American developments (early 1960s) and before Rolls Royce. Professor Shih gave me the impression that the institute keeps up with the state-of-the-art in superalloys and has excellent technology transfer to the engine industry.

- Molybdenum Alloys

A wrought Mo-30 W alloy has been developed which has high strength, good ductility, and resistance to corrosion by molten zinc.

- Titanium Alloys

A model has been developed for the design of titanium alloys with improved thermal stability. Using the electron concentration concept, the correlations between formation of ordered Ti_3X phase (were X = Al, Ga or Sn) and electronic structure of

alloying elements have been investigated for several transition metals (Sc, Zr, V, Nb, Mo) and interstial elements (O,C,N). Based on these correlations a characteristic electron concentration criterion has been proposed and a phase calculating model has been established.

Other alloying studies are directed toward improving the corrosion and passivation behavior of titanium alloys. The influence of Mo, Nb, W, Ta, Pd, Y, etc., on the composition of the passive film has been studied by ESCA (electron spectroscopy and chemical analysis).

Phase transformations of thermoelastic martensite and the shape memory effects are being investigated.

- Cryogenic Steels

This group served as my host, and thus, several staff members were met. The group leaders are Mrs. Y.Y. Li and Mrs. Y.Y. Guo; both are assocate professors. The research includes phase transformation studies, metallography, mechanical and physical properties, and alloy development. I visited the magnetic balance, the liquifier, and the metallographic laboratories. In addition, I had discussions with five graduate students or young staff members: Mr. Liang Guo-jun, Mr. Lai Weng-jin, Mr. Lin Yong, Mr. Lei Ming, and Mr. Mei Ze-gun. Most of the students were involved in structure/properties studies on 9% Ni steel, which is used for liquified natural gas (LNG) storage and handling.

The magnetic balance was recently purchased from George Associates (U.S.A.). Mr. Chai Shou-sen showed me the unit. It is a magnetic susceptibility force magnetometer used for phase transformation studies. It is being used to study austenitic steels which transform upon cooling to cryogenic temperature. The temperature capabilities are 4 K to 1200 K.

The liquifier laboratory is equipped with a nitrogen liquifier and a 10 liter/hour helium liquifier. Both units are made in China. The units were shown to me by Mr. Fan Cun-gan.

The metallography laboratory for this group is the best in the institute and provides services to other groups. It includes a complete line of Buehler (U.S.A.) equipment, vintage 1981. Apparently, Buehler used the institute staff and facilities to demonstrate their wares to the China market. In return, they simply left the equipment with the institute upon completion of the demonstration. Mrs. Li had just returned from a two-month visit to the U.S.; six of these weeks were spent as the guest of Buehler where she was able to use some of their latest equipment.

- Alloy Steels

Recent work has led to the development of a maraging steel with a superfine grain size and good properties. It is being touted as a drill steel with substantially longer life.

- Role of Rare Earths in Steel

Research has been continuing since 1965 on the use of rare earths for inclusion shape control in steels. A collection of color metallographs has been compiled showing typical rare earth inclusions in steels. The problem of nozzle blockage during teaming of rare-earth treated steels has been studied and a mechanism proposed.

- Amorphous and Liquid Metals

Research on amorphous metals was started in 1977. The group is under the direction of Professor Wang Jing-tang. Basic research is being conducted on the formation, crystallization, and hydrogen embrittlement of amorphous metals. Applied research is directed toward the development of magnetic materials and the relationship between glass formability and the properties of liquid metal.

The laboratory is equipped with a program-controlled, melt spinning apparatus; it is basically a rotating (30 m/s) water-cooled copper drum with an induction heated quartz crucible mentioned above. Cooling rates of 10^6°C/s are possible. Argon is used as a protective atmosphere. The unit was designed and built by the institute. A new unit, also designed and built by the institute, is nearly ready for use. It features twin rollers in a vacuum chamber and a similar crucible arrangement. The group also has a sputtering unit for making thin films, and a Perkin Elmer TMS-II equipped with an institute-designed quartz probe that can measure expansion coefficient with an accuracy of 1×10^{-5} mm.

The laboratory was shown to me by Mr. Wang Lung-ban. Several examples of amorphous metal strip (up to about 50 mm in width and 10 to 50 μm in thickness) were shown. Alloys included $Fe_{40}Ni_{40}P_{14}B_6$ NiCrSiB, FeCoSiB, and $Cu_{58}Zr_{42}$. Two papers presented at the Fourth International Conference on Rapidly Quenched Metals [Sendai, 1981, see this *Bulletin, 6* (4) 1, (1981)] written by Wan Jing-tang *et al.*, were given to me: "The Chrystallization Kinetics of Fe-Ni-P-B and Cu-Zr Glass," and "Hydrogen Embrittlement of $Fe_{40}Ni_{40}P_{14}B_6$ Glass." These were the only papers that I received from the IMR.

- Practical Superconducting Materials

The IMR started research on NbTi and Nb_3Sn multifilamentary superconductors in 1980. These are the two most common superconducting materials for practical applications, and it appears that the institutes' effort is simply to develop the technology to produce composite superconductors. Processing, heat treatment, and alloying (matrix modification) are being studied. Professor Shih mentioned that the pilot plant extrusion equipment (Department of Technological Development) is being used to produce the superconductors for laboratory purposes.

- Materials with Special Properties

Research and development activities cited in the brochure include plasma spray coatings for thermal protection, hollow cathode discharge ion plating, wear-resistant TiN coatings for decorative purposes, boron filament production by continuous vapor deposition, TiB_2 barrier coatings for carbon filaments used in composites, SiC for high temperature erosion resistance and titanium disulfide (intercalated) for cathodes in secondary batteries. In short, they appear to conduct developmental work on special purpose materials needed by a variety of industries.

- Carbon Material

The institute has various pyrolytic graphite deposition furnaces and testing facilities. They have the capability of making shapes, fibers for composites, and carbon-carbon composites.

NEW TECHNOLOGIES AND PROCESSES

This Division consists of eight research groups, most of which appeared to be centered about a particular type of equipment. As in the previous section, I only visited two of the groups (acoustic emission and welding), and thus, the discussion of the others is limited to information in the brochure.

- Acoustic Emission (AE) Technique

This group is led by Professor Zhu Zu-ming who presented a paper entitled, "Application of Acoustic Emission Technique to Fracture Test," at the ICF International Symposium on Fracture Mechanics [(Beijing, 1983), see previous report]. This study showed a linear relationship between crack area and accumulated AE energy. Acoustic emission research was started in 1972 (first in China) and a high level of competence is apparent. The laboratory, shown to me by Mr. Fan Shi-yu, has recently (1983) purchased a Dunegan-Endeavco (U.S.A.) acoustic emission research facility for detecting and analyzing signals from multiple tranducers (seven Dunegan-Endeavco transducers were mounted on a pressure vessel plate under study) and finding the source by triangulation. The unit will be used to develop pressure vessel inspection techniques. The laboratory also has a servohydraulic fatigue machine for research on nucleation of microcracks, fracture of composites, stress corrosion cracking, and fracture toughness. The original AE equipment which was built by the institute is still used for most of these studies. In basic research, AE was used to detect liquid to solid and solid state phase transformations. In one study, the Si-Bi binary phase diagram was successfully reproduced by the AE method. The results of this study are reported in the *China Journal of Metals*.

- Instrumental Analysis and Infrared Radio-thermography

Near surface concentration gradients of elements in protective coatings, corrosion layers, and intergranular fracture surfaces have been studied using spectroscopic methods. The glow discharge source used in spectroscopic chemical analysis has been developed and its sputtering and excitation mechanism has been studied. The technique (and associated standards) is claimed to be a new tool for materials research.

An infrared sensing device (radiometer) is used to measure the thermoelastic effect (temperature decrease upon tensile stressing). The relationship between stress fields and temperature fields during elastic-plastic deformation was established using finite element analysis. The method is being used to map deformation patterns in notched tensile panels in fracture mechanics research programs.

- Analysis of Gases in Metals

More than 40 methods for gas analysis and 28 sets of apparatus have been used by the institute to determine the surface, dissolved, and total gas contents of metal samples. Methods include vacuum hot extraction for hydrogen, vacuum fusion for oxygen, vacuum fusion-purified separation mass spectrometry for argon, induction-heating carrier gas for rapid determination of hydrogen, and impulse-heating gas-chromatographic analyzer for oxygen, nitrogen, and hydrogen.

- Metallographic and Electrochemical Analysis of Phases

Techniques have been developed for potentiostatic differential etching and electrolytic deep etching to reveal alloy phases and observe their morphology.

- Special Melting Technique

Research is conducted using the vacuum induction melting and electron beam refining processes. Studies include evaporation of alloying elements, reduction of oxygen, nitrogen, and sulfur during vacuum processing, and liquid metal and crucible reactions.

- Mechanical Working of Metals

Projects are being inducted on the development of dual phase sheet steels, superfine wires, special alloy pipes, superplastic air bulge forming, and high deformation rate forming.

- Special Welding and Cutting Technology

Since 1958, the institute has developed many techniques including plasma arc cutting and welding, electron beam welding, gas tungsten arc welding in vacuum, condenser discharge resistance welding, vacuum brazing, and diffusion bonding. Current research includes laser surfacing (their 2 kW laser is not powerful enough for welding), diffusion bonding of aluminum honeycomb sandwich panels, and relief of residual stresses using an explosive technique.

- Applications of Computers to Materials Science Research

During the laboratory visits, numerous computers were observed being used for real time data analysis, controlling experiments, etc. Apparently, a separate group uses computers for studies such as dislocation modeling, internal friction studies, phase diagram generation, and crystallography. In short, the computer is a familiar and practical tool at the IMR.

TECHNOLOGICAL DEVELOPMENT

The Department of Technological Development is responsible for producing new materials in small batches for use by other research groups in the IMR, and for transfering technology from the institute to industry. It was created during the cultural revolution while the institute was part of the Ministry for the Metallurgical Industries. However, it continues to provide valuable service and was highly praised in discussions with Professor Shih.

The main facilities include:

- 150 kW electron beam furnace,
- 200 kg vacuum induction furnace,
- 530 T hydraulic extrusion press,
- LD series cold rolling pipe mill,
- 750 kg forging hammer, and
- facilities for precision investment casting.

New equipment under installation (1982) are:

- 300 kW electron beam furnace,
- 1 T electroslag furnace,
- 1 T vacuum consumable arc furnace,

- 500 kg induction furnace,
- 630 T double stroke punch press,
- 630 T hydraulic forging press,
- equipment for powder production.

SUMMARY COMMENTS

The Institute for Metal Research is engaged in materials research ranging from high resolution electron microscopy at the atomic scale to pilot plant production of metals, alloys, and composite materials. There appears to be a sensible balance of basic and applied research. Professor Shih has established two criteria for research programs. First, basic research must be at a world-class level, and second, applied research must contribute to the needs of industry. The criterion for basic research limits the number of basic programs, but there are selected scientists working with state-of-the-art equipment who appear to get generous support for their basic research programs. In addition, the graduate students often get basic research projects that result in a continual flow of new ideas throughout the laboratory. The criterion for applied research is easily met by many programs because of the low level of development in Chinese industry. Yet it remains a sensible criterion for the development of research projects and the measurement of performance. Applied research is the norm and is done on all physical metallurgy topics with the notable exception of carbon and low alloy steels. Ferrous metallurgy and chemical metallurgy are apparently covered by other institutes.

The graduate education programs proceed within the same organizational framework as the research programs. A student is assigned to the laboratory of his professor and does research within the scope of that group's responsibility.

Development and technology transfer are accomplished through close ties developed over the years with many industries. Prime examples are superalloy development for aircraft engines, development of production technology for titanium, development of new applications for rare-earth metals, and the development of advanced welding technology such as electron beam welding and plasma arc cutting. Technology transfer is facilitated by pilot shop facilities capable of making small lots of new alloys.

Many of the laboratories are equipped with modern equipment purchased from leading companies of the U.S., Japan, and Europe. Apparently two or three "big ticket" items are purchased abroad each year. Professor Shih puts a high priority on such purchases and must personally sell the appropriate officials on the merits of such equipment. His current hope is to get a scanning transmission electron microscope. The expensive foreign equipment that I saw was typically in laboratories that included previous generation equipment, often made by the institute, of the same type. Thus, experienced personnel were available to select the best available equipment and to use it when it arrived.

The institute makes extensive use of microprocessor controls and minicomputers in its materials research activities. Computers are often part of the "big ticket" items; e.g., the electron microprobe, the magnetic balance, the weld cycle simulator, and the acoustic emission system all came equipped with computers.

The IMR has an international outlook. About three staff members study abroad each year, usually in the U.S. For example, I met three staff emembers who plan (according to their supervisors) to do research in the U. S. starting in 1984 or 1985; one at the University of California, Berkeley, and two at the National Bureau of Standards. These

three men were from a single research group, cryogenic steels. Professor Shih puts great emphasis on English training. The IMR has hosted visitors from the U.S. (who taught English) for nearly a year. Staff members were encouraged to study English during working hours. Staff selected to study or do research abroad are sent to language school prior to leaving China. The English-speaking capability was apparent during discussion periods and laboratory visits. A high percentage of the staff could speak some English.

In summary, I was very impressed with the IMR. They appear to be making an important contribution to the science and technology base in the People's Republic of China, and are capable of contributing to the materials sciences internationally.

JAPANESE SUPERCOMPUTERS

George E. Lindamood

INTRODUCTION

In July 1982, Japan's largest computer maker, Fujitsu, announced what it called the world's fastest supercomputer, the VP-200, capable of up to 500 megaflops. (1 megaflop = 1 million floating-point operations per second.) Two months later, Fujitsu's archrival, Hitachi, announced its S810, rated at 630 megaflops. To nobody's surprise, NEC Corporation (formerly Nippon Electric Company, Ltd.) followed suit in the spring of 1983, and to nobody's surprise, NEC's machines, called the SX-1 and SX-2, are touted to be even faster than those of Fujitsu and Hitachi.

The first of these Japanese supercomputers to be delivered was Hitachi's S810, which was installed at Tokyo University's Computer Center in mid-October 1983. (Actually, this was Hitachi's second S810; the first was installed two weeks earlier at Hitachi Central Research Laboratory in Kokubunji.) Fujitsu's first system, a VP-100 (which is rated at half the speed of the VP-200), was delivered to the Institute for Plasma Physics--which is affiliated with Nagoya University in much the same way that Lawrence Livermore Laboratory is affiliated with the University of California--in mid-December 1983. (Fujitsu says that a prototype VP-200 system had been in operation at its Numazu facility for several months before that.) Initial shipments of the NEC supercomputers will be not made until the first quarter, 1985, although NEC indicated that a prototype system will be ready for benchmarking at its Fuchu facility by mid-1984. Who will get the first NEC machine has not been disclosed, but Osaka University's Computer Center (which has received early production models of previous top-of-the-line NEC systems) is a good bet.

Now that the first Fujitsu and Hitachi machines have been delivered, a logical question is: Who will be the next customers for Japanese supercomputers? Neither Fujitsu nor Hitachi has announced anything of this kind, although all three manufacturers are predicting sales of 30 to 50 systems each during the next few years. To be sure, the Japanese would like very much to sell their supercomputers abroad, if only for the prestige resulting from winning such sales in (presumed) competition with the likes of Cray and CDC. Hitachi is rumored to be considering marketing the S810 in the U.S. through NAS, which presently markets other large Hitachi-made IBM-compatible systems. Fujitsu is said to be exploring sales of its supercomputers through Amdahl in the U.S. and ICL in the U.K. NEC's ties with Honeywell have come undone in recent years, to the point that those two companies have been competing for sales of large computer systems to GE's computer service bureau, but NEC has expressed strong interest in selling SX systems to the U.S. defense establishment.

An even more pertinent question (in my mind, at least) is: Why?--Why are the Japanese putting all of this R&D effort into supercomputers? Other computer manufacturers worldwide appear to be steering clear of the supercomputer market because:

- the risks are too high,
- the potential market is too small, and/or
- the potential return-on-investment is much greater in other market segments--for example, office automation.

The conventional wisdom used to be that, although supercomputer development might not be very profitable in and of itself, the resulting concepts and technologies could be employed in later generations of smaller systems. Recently, this rationale has been questioned, perhaps because of the somewhat tenuous connection between the rather specialized architectures and applications of supercomputers, on the one hand, and those of, say, personal computers, on the other.

Nevertheless, when I put these questions to representatives of Fujitsu, Hitachi, and NEC, they responded with the standard set of reasons:

- the Japanese feel that there is a considerable market worldwide for supercomputers,
- they feel that supercomputers provide an excellent test bed for new high-speed circuit technology,
- the Japanese feel that their society--and, by extension, the world in general, especially the scientific community--will need ever bigger and faster supercomputers in coming years, so Japanese companies are morally obligated to try to meet that need, and
- there is considerable prestige associated with building the world's most powerful computer systems.

HITACHI'S S810 SYSTEM

That Hitachi was able to deliver its supercomputer some two months ahead of Fujitsu even though Fujitsu's announcement had preceded Hitachi's by the same interval is not to surprising when the design of the S810 is compared with that of other extant Hitachi systems. The circuit technology is essentially the same as used in the Hitachi M280H: 550 gates/chip emitter coupled logic (ECL) LSI with a gate delay time of 350 psec; and 1500 gates/chip ECL LSI with a gate delay time of 450 psec. (Both chip types have 108 pins and dissipate about 3.3 W of power per chip. Both are manufactured using (2 μm) electron beam lithography, reactive ion etching, and three-layer metallization.) The principal difference is that chips are mounted on both sides of 14-layer printed circuit cards in the S810, but only on one side of 10-layer cards in the M280H. (In both systems, the circuit cards plug into 18-layer mother boards.) Also, the S810 has a closed-loop water system to keep the air (which actually does the cooling) from getting too hot as it passes through successive banks of circuitry.

Even architecturally, the S810 is a close derivative of previous Hitachi machines. The scalar portion of the CPU is essentially identical with the M280H CPU, and the vector portion of the S810 is a fairly straightforward extension of the Integrated Array Processor (IAP) which can be added to M280H systems to implement vector processing instructions. (Unlike IBM's 3838 array processor which appears to the CPU something like a data channel in that it executes a separate sequence of instructions after being started by the CPU, the IAP takes its instructions from the same sequence as the CPU; the IAP executes the vector instructions, and the basic CPU executes the rest.) The scalar instruction repertoire is the same as that of the M280H, which is essentially IBM compatible. The vector instruction repertoire consists of 80 instructions: arithmetic operations; logical operations; vector moving, loading, and storing; comparison and conversion; searching (e.g., finding maxima and minima); and macro arithmetic operations such as inner product and first order iteration. Whereas the IAP has only one execution unit, the S810 has a set of five (pipelined) execution units: two adder/shifter/logical units, a multiplier/divider unit, a multiplier unit, and a mask operation unit. Together, these units comprise the vector processing unit of the S810.

The S810 is available in two models: the Model 10 has one vector processing unit, and the Model 20 has two. The Model 10 has sixteen 256-word--64 bits/word--vector registers (implemented with 1K-bit bipolar chips with 4.5 nsec access time), 16 scalar registers, and 64K bytes of buffer storage, while the Model 20 has 32 vector registers, 32 scalar registers, and 256K bytes of buffer storage. Both models have eight 256-word vector mask registers and 48 vector address registers. If each pipeline performs one operation per (14 nsec) machine cycle, the Model 10 can attain a peak performance of about 357 megaflops, and the Model 20 double that. However, for unexplained reasons, Hitachi rates the Model 10 at 315 megaflops and the Model 20 at 630 megaflops. (The IAP is rated at about 33 megaflops.)

The other principal difference between the S810 and the M280H is in the memory. The M280H uses 64K-bit dynamic MOS with an access time of 120 nsec, but the S810 uses 16K-bit static MOS with a 40 nsec access time. Also, the maximum memory size for the M280H is 32 megabytes, while the S810/10 can have up to 128 megabytes and the S810/20 up to 256 megabytes. The S810 is also equipped with a high-speed semiconductor memory with a capacity of 128 to 1,024 megabytes and a data transfer rate of 500 (on the Model 10) or 1,000 megabytes per second. This "extended storage" (as Hitachi calls it) is accessed like a disk drive and is intended for "staging" of large quantities of data which cannot be contained in main memory. Hitachi claims that the extended storage significantly improves performance over that attainable with only disk units plus main memory.

Although the S810 is capable of stand alone operation, the preferred configuration is loosely coupled (via channel-to-channel adapter and shared disks) to an M280H processor which acts as the "front end" to the S810. (At Tokyo University, the S810/20 is loosely coupled to three M280H systems, each of which also includes an IAP.) The front end handles all multiprogramming because the vector processing unit is not interruptable. For this reason, only Hitachi systems--not even Hitachi-made NAS systems--can be used as the front end at present time. Also, the extended storage is supported only by Hitachi software. (Hitachi admits that both these factors seriously undermine the viability of the S810 in markets outside Japan, but perhaps their recently concluded agreements to license IBM software will clear the way for them to make the S810 operable with IBM front end systems.)

Hitachi's program products for the S810 include a FORTRAN 77 compiler for vector processing and a "vectizer" tuning tool. Because the peak rated speed of the S810 can be attained only when the vector processing unit is being fully utilized, the FORTRAN compiler attempts to generate as much "vectorized" code--that is, code containing only "vector" instructions--as possible. To do this, the compiler automatically reconstructs "DO" loops and analyzes "IF" statements; it also permits the programmer to specify program segments in which vectorization is forced (or suppressed). The vectizer provides information such as vectorization ratios, execution ratios for DO loops, and vectorization diagnostics, all of which may be useful to the programmer in writing source code which the compiler can vectorize better.

FUJITSU'S VP SYSTEMS

Like the Hitachi S810, the Fujitsu VP supercomputer systems utilize essentially the same circuit technology as the company's other large computer systems, in particular the Fujitsu M380 and M382. (The M382 is a dual processor version of the M380.) ECL LSI chips with 400 or 1,300 gates per chip and 350 psec gate delay times are used for logic. One hundred twenty one LSI chips are mounted on (one side of)

14-layer printed circuit boards which are 31-by-31 cm^2. These boards are then assembled into a "stack" with 12-layer interconnect boards on two sides. Even the memory chips used for registers and buffer storage are the same in the VP and M380/382 systems: 4K-bit bipolar RAM chips with 5.5 nsec access time. Like Hitachi, however, Fujitsu uses different chips in the main memory: 64K-bit static RAM chips with 55 nsec access time are used in the VP systems, as compared with 64K-bit dynamic RAM with 150 nsec access time in the M380/382. In January 1984, Fujitsu announced the "test manufacture" of a new 256-bit S (static random access) RAM chip, using high electron mobility transistors. Over 2000 transistors are packed into a chip only 2.3 mm^2. An access time of 1.5 nsec at 77°K was claimed, and still bigger chips are nearly ready.

Architecturally, Fujitsu also uses the M380 design for the scalar portion of the VP system, but, unlike Hitachi, Fujitsu has not previously implemented vector instructions in its line of IBM-compatible computers. One must go way back to 1977 to find a progenitor for the VP; an Array Processor Unit (APU) was designed for the Fujitsu 230-75, but only two were actually delivered. Like Hitachi, however, the 195 instructions in the scalar instruction repertoire comprise essentially the standard IBM instruction repertoire, such as is used in the IBM 308X systems. The VP vector instruction repertoire is almost exactly the same as that of Hitachi's S810.

Indeed, the internal architecture of the Fujitsu VP bears a considerable resemblance to that of Hitachi's supercomputers. However, the Vector Unit of the VP system has only one add/logical pipeline (as compared with two in the S810); it also has one multiply pipeline, one divide pipeline, and one mask operation pipeline. Like Hitachi, Fujitsu offers its supercomputer in two configurations: the VP-100, rated at 250 megaflops; and the VP-200, rated at 500 megaflops. The VP-100 has 32K-bytes of Vector Registers and the VP-200 has 64K-bytes, which is the same as the S810, Models 10 and 20 respectively. However, Hitachi's vector registers are each 256 words in length, whereas Fujitsu's can be dynamically reconfigured (with no degradation in performance, Fujitsu claims) as 256 32-word registers, 128 64-word registers, etc., to eight 1024-word registers. Fujitsu's Mask Registers are considerably smaller in capacity than Hitachi's: 512 bytes and 1,024 in the VP-100 and 200, respectively, as contrasted with 16K-bytes in both models of the S810, but the VP has four extra floating-point registers in the scalar unit. What differences in performance might result from these different register configurations is very difficult to predict, however.

In main memory size, the VP-100 is the same as the S810/10, and the VP-200 is the same as the S810/20, but the two systems differ in the way the Vector Unit is interfaced to the main memory. In the Fujitsu system, the Vector Unit has two load/store pipelines; in the Hitachi system, the Vector Processing Unit has two load units and one store unit. Again, which configuration is superior in any particular application is difficult to predict. However, Fujitsu has no high-speed extended storage unit like Hitachi's, which is probably a disadvantage. (Curiously enough, the Fujitsu M380 and M382 have <u>three</u> levels of semiconductor memory: up to 128 megabytes of 150-nanosecond-access-time "main" storage using 64K MOS RAM chips; 64K-bytes of 5.5-nanosecond-access-time "local buffer storage" in each arithmetic unit using 1K bipolar RAM chips packaged four per module; and between these two, 256K-bytes of 16-nanosecond-access-time "global buffer storage" housed in the memory control unit and using 4K MOS RAM chips also packaged four per module.)

In software, however, Fujitsu appears to have a clear advantage over Hitachi, at least in what has been announced to date. The Fujitsu FORTRAN 77 compiler appears to be more or less equivalent to Hitachi's in the approach to generating object code which is highly vectorized. However, the Fujitsu compiler is supported by both a

compiler/library of high-speed object modules and a scientific subroutine library containing more than 220 highly vectorized subprograms (such as FFT's, fast tridiagonal equation solvers, eigenvalues and eigenvectors, etc.). In addition, Fujitsu's tuning and debugging tools are interactive (whereas Hitachi's operate only in batch mode) and appear to be more extensive than those for the S810.

Also, Fujitsu VP systems can operate in stand alone or in closely-coupled configurations with channel to channel and shared disk interconnection with front end systems, but Fujitsu's supercomputers (unlike Hitachi's) will operate with IBM systems (running MVS) as well as Fujitsu's own. Therefore, to the extent that the existence of IBM compatibility and more extensive software indicate such things, Fujitsu's supercomputer systems appear to be more thoroughly thought out than those of Hitachi. Perhaps this is simply a reflection of Hitachi's strong desire to market a system more powerful--on paper, at least--than Fujitsu's and to install their system first.

NEC'S SX SYSTEMS

NEC is clearly out of the running in the race to deliver the first of this generation of Japanese supercomputers, but they claim that their systems will be worth waiting for. Named the SX-1 and SX-2--SX is for supercomputer extended--NEC's machines are claimed to be capable of processing speeds up to 570 megaflops and 1.3 Gigaflops, respectively. However, these are peak processing speeds, attainable only under certain conditions.

The SX-2 has four independent vector pipelines (and the SX-1 has two), each operating at a cycle rate of 6 nsec (7 nsec on the SX-1). Each pipeline contains four essentially independent processing units: one for add/subtract, one for multiply/divide, one for logical operations, and one for shifting operations. Although it is conceptually possible for all 16 of these units to be in operation simultaneously, the maximum rate at which the main memory unit is capable of delivering data is 11 billion bytes per second. That figures out to slightly more than eight 64-bit operands per cycle, which would restrict concurrent floating-point operations to four. However, when the results of one vector operation are to be immediately utilized by a subsequent operation, the hardware utilizes vector registers rather than return the results to main memory. (This is called chaining.) Therefore, it is possible that all four add/subtract units and all four multiply/divide units could be operating simultaneously (if the add/subtract and multiply/divide operations in each pipeline can be chained), thereby performing 8 floating-point operations every 6 nsec, which would yield an overall processing rate of 1.333, etc., Gigaflops.

Even that rate can be sustained only in bursts, during which vectors containing multiple elements are processed by each pipeline. Although floating-point operations can be initiated by each add/subtract and multiply/divide unit in each pipeline at the beginning of each (6 nsec) machine cycle, it takes about 8 cycles for each operation to actually be completed, so that the effective processing rate is somewhat reduced at the beginning and end of each vector. The length of vectors is limited by the size of the vector registers: 80K-bytes in the SX-2 and 40KB in the SX-1.

Because there are often significant portions of scientific computations which cannot be vectorized, the SX-1 and SX-2 also have a scalar processing unit, which operates independently of the vector processing units. The scalar unit is also internally pipelined to attain high processing rates (as is the case with the Hitachi and Fujitsu machines); it has a high-speed branch system and 128 scalar registers. In addition to

single (32-bit) and double (64-bit) precision arithmetic, the scalar unit has built-in extended precision (128-bit) processing capability. In scalar processing, NEC claims that the SX-1 is more than twice as fast as the Fujitsu VP-200, the Hitachi S-810/20, or the Cray-1S and that the SX-2, which is about 10% faster than the SX-1, is more than twice as fast as the Cray X-MP.

The vector processing units and scalar processing unit together comprise the Arithmetic Processor in the SX-1 and SX-2. There is also a separate Control Processor which runs/handles memory management, oversees input/output operations (which are actually handled by a separate Input/Output Processor), etc. The Input/Output Processor has up to 32 data channels, with total data transfer up to 50 megabytes/second, which is about the same as the I/O capabilities of the Hitachi and Fujitsu systems.

NEC's Main Memory Unit (MMU) has a capacity of 64, 128, or 256 megabytes, with 512-way interleaving (256-way in the 64MB version). As with the Hitachi S810, there is also a large extended semiconductor memory unit, but with capacity up to 2 Gigabytes. Also, as with the S810, this unit appears like a file to the system; data must be transfered between it and the MMU through a memory move operation in the Control Processor. The MMU is made of 64K MOS static RAM chips with 40 nsec access time. NEC has hinted that the Extended Memory Unit will use 256K MOS dynamic RAM but has deferred announcement of that (because of "present sensitivities of U.S. semiconductor manufacturers," according to my source). The cache memory and registers in the Arithmetic Processing Units are made of 3.5 nsec, 1K bipolar chips. The logic circuitry is 1,000 gate-per-chip Current Mode Logic (which NEC says is "not quite the same thing as ECL"), having a delay time of only 250 psec per gate. It is packaged with 36 chips mounted on a 10 cm^2 ceramic substrate, and water cooling is used (for the first time in any major Japanese computer system).

Like Hitachi and Fujitsu, NEC's SX software is essentially FORTRAN-centered. There is a FORTRAN 77 compiler which generates object code for the Control Processor and a FORTRAN 77/SX compiler which generates vectorized object code for the Arithmetic Processor. Both compilers run on the Control Processor.

The SX machines can be operated in stand alone mode, although it remains to be seen how well TSS and RJE can be supported in a system which does not have virtual storage or demand paging. SX systems can also be coupled to other NEC ACOS-series systems via NEC's Loop 6770 fiber optic local area network system or via a direct channel-channel connection (which will probably be the most common configuration). Loosely-coupled (channel-to-channel) IBM-SX systems are also contemplated, but probably without shared disk files. (The data formats of the SX are IBM-compatible.)

APPLICATIONS

Judging from their descriptive brochures, Fujitsu, Hitachi, and NEC expect their supercomputers to be used in the usual sort of applications:

Aeronautics and Space	Aerodynamics, structural analysis, and image processing
Nuclear	Reactor analysis, safety analysis, particle simulation
Meteorology	Numerical weather forecasting, global atmospheric circulation simulation

Molecular science	Molecular structural analysis, molecular orbit calculation
Geophysics	Electromagnetic analysis, seismic analysis
Civil Engineering	Structural analysis, vibration analysis
Mechanical Engineering	Structural analysis, thermal analysis
LSI Design	Device analysis, circuit analysis, layout design.

However, it would seem that new areas of supercomputer application--for example, computer animation for movies and television--will be needed if these Japanese companies are to realize their sales projections.

SUMMARY

Although the relative performance of the S810, VP, and SX supercomputer systems will have to be determined by future benchmarking, the Japanese have undoubtably made an impressive entry into the supercomputer field. Moreover, Fujitsu, Hitachi, and NEC claim that they are in the supercomputer business to stay, regardless of how many (or how few) of the current models they sell. Already they are at work on refinements and enhancements of these machines, as well as future models. Certainly, their accomplishments and their plans should not be taken lightly.

ENGINEERING EDUCATION AT THE JAPANESE NATIONAL DEFENSE ACADEMY

George E. Lindamood

INTRODUCTION

The Japanese National Defense Academy is the institution which educates and trains the cadets who are to become officers of the Japanese Self-Defense Forces (JSDF). As such, it is the Japanese counterpart of the United States Military Academy (West Point), Naval Academy (Annapolis), and Air Force Academy (Colorado Springs).

The Academy was originally established on 1 August 1952, as the National Safety Academy. It admitted its first class of 400 cadets, of which 300 were for the Ground Safety Force and 100 for the Maritime Safety Force, on 1 April 1953. With the passage of the National Defense Agency Law on 1 July 1954, the name of the Academy was changed to the National Defense Academy. In the following year, the authorized size of each class was increased to 530 to provide officers for the newly formed Air Self-Defense Force. (What were previously the Ground Safety Force and the Maritime Safety Force were renamed the Ground Self-Defense Force and the Maritime Self-Defense Force, respectively.)

Originally housed in a temporary building at Kurihama, Yokosuka, Kanagawa Prefecture, the Academy is now located atop Obara-dai, a plateau 85 meters (278 feet) above sea level, overlooking the mouth of Tokyo Bay. With more than 30 major (white concrete) buildings situated in a well-landscaped 629,000 square meter (155 acre) plot, the physical setting of the Academy is impressive in its spaciousness, extent, and beauty. The library, located in the center of the campus, has more than 370,000 books in its collection. In addition to the main campus, there is also a beautiful harbor at the foot of the Obara-dai plateau where boats for training and recreation are moored.

Applicants to the Academy must be Japanese male citizens between the ages of 18 and 21 (or between 18 and 23 in the case of persons in active service in the National Defense Forces). They must have completed high school (or the equivalent thereof) or the third grade of a higher technical school. The entrance examination consists of a written examination, a personal interview, and a physical examination.

THE CURRICULUM

In addition to four administrative departments (including the library), the various departments of the National Defense Academy are as follows:

Liberal Arts
Physical Education
Electrical Engineering
Civil Engineering
Applied Physics
Ground Defense Science
Air Defense Science
Social Sciences
Mathematics and Physics
Mechanical Engineering
Aeronautical Engineering
Chemistry
Maritime Defense Science

The first year of study is essentially the same for all cadets, consisting of basic courses in what the Academy calls "general education:" liberal arts, social sciences, and natural sciences. All cadets also receive general military training to understand the purposes and functions of the three services of the National Defense Forces. At the end of the first year, the cadets are assigned to the respective services--at present, 300 to the Ground Self-Defense Force, 100 to the Maritime, and 130 to the Air--after careful consideration of the personal desire of each cadet, his aptitude for the particular service, and the physical requirements demanded by each service. Subsequent military training differs according to the service, with special consideration given to instilling in cadets the principle of cooperation with each of the other two services.

All cadets are required to take two hours of field training each week, as well as six-week regular training courses each year. Physical education is required all four years of study, and all cadets must also participate in specialized training such as skiing and swimming. Total training amounts to 1,176 hours.

Some general education courses are also taken in the second year, at which time cadets begin study in the major subject of their choice (subject to approval by the branch of service to which they have been assigned). Prior to 1974, all cadets followed an Engineering Course, majoring in Electrical Engineering, Mechanical Engineering, Civil Engineering, Aeronautical Engineering, Applied Physics, or Applied Chemistry. More than 85% of the cadets still do this. However, since 1974 cadets can also choose a Social Science Course, majoring in either Management Science or International Relations. The requirements of the Engineering and Social Sciences Courses are summarized in Table I.

Also, cadets in the Engineering Course must take "Fundamentals for Scientists and Engineers" (25 units), "Introduction to Engineering" (13 units), at least 43 units in their major subject, and at least 14 units of electives. In addition to what is specified in Table I, cadets in the Social Science Course must take at least 78 units in their major subject and 12 units of engineering electives. (One unit consists of 15 hours of lectures--one hour per week for 15 weeks--in the case of classroom lectures, or 30 hours of seminars--two hours per week--in the case of seminars (such as mathematics or foreign languages), or 45 hours of experiments, exercises, etc.,--three hours per week--in the case of laboratories and practicing facilities. Cadets normally enroll for 20 to 24 units each term. Classes are held Monday through Friday and Saturday mornings.)

During their fourth year, the cadets also carry out research projects in their respective specialized fields, as is the case in Japanese civilian universities. The "equivalent B.S. degree" is awarded because the Academy is part of the Japanese Defense Agency, not the Ministry of Education, but Academy graduates are entitled to enter the postgraduate course of any civilian university (if they can pass the entrance examinations).

Upon graduation, the cadets are appointed Master Seargeant or Chief Petty Officer 1st Class as "Officer Candidates." After a short leave, they are required to enter the Officer Candidate School for their respective branch of service. At these schools, they are integrated with other Officer Candidates from the enlisted ranks and civilian universities, all receiving rigorous training for one year. They are then commissioned as officers and assigned immediately to various units of the National Defense Forces.

After serving a few years, a certain number of officers are given the opportunity to attend either the postgraduate course of a civilian university in order to obtain a master's degree and/or doctorate, or to attend the National Defense Academy Postgraduate Course. Typically, about three Academy graduates begin postgraduate

studies in Japanese universities each year; one or two more do likewise at American universities.

THE POSTGRADUATE COURSE

The National Defense Academy established the Postgraduate Course in Science and Engineering on 1 April 1962, for the purpose of educating and training officers who had graduated from the National Defense Academy as well as other officers and civilian officials serving the National Defense Agency. Initially, the postgraduate course consisted only of Electronics Engineering, but later the course was reorganized and expanded to seven departments, covering 45 areas of study, as shown in Table II.

The level of the postgraduate course is equivalent to that of the master's degree courses of Japanese civilian universities. In order to graduate, the students study for two full years, living on the Academy campus. They are required to complete a minimum of 32 units in compulsory and elective subjects, to write a thesis, and to pass a comprehensive examination. About 90 students (including two or three women) are admitted to the program each year. The principal entrance requirement is a written examination.

COMPUTER SCIENCE

Because of my particular interest in computer science, I gave special attention to the computing facilities and the computer-related portion of the curriculum during my visit to the Academy. The Computer Center has a large Hitachi M-200H system with 12 megabytes of main memory and more than 5 gigabytes of disk storage. System performance is claimed to be 12.9 MIPS for the Academy's single CPU configuration, although there is also an Integrated Array Processor which provides high-speed vector processing. The system is operated primarily in time-sharing mode (without an operator in attendance) from 0830 to 2130 hours Monday through Friday, plus Saturday mornings.

About 100 terminals, most of them the "glass Teletype" CRT variety, are attached to the system, using "spare" telephone lines which were installed when the campus was built. Terminals using dedicated lines operate at 9600 bps; those connected through multiplexers operate at 1200 bps. Each department has its own terminal, and each of the eight cadet dormitories has two terminals. Cadets are issued mag stripe ID cards which they insert into special terminals to claim their printed output.

All computer science instruction at the Academy is handled by the Department of Electrical Engineering. That department, followed closely by the Department of Mechanical Engineering, is the largest in the Academy; about 150 cadets per year, 16 postgraduate students (two in each specialty) per year, and 70 faculty members. To date, it has graduated over 3000 cadets and more than 300 postgraduate students.

Beginning in 1982, all cadets expecting to follow the Engineering Course are required to take nine units of mathematics and two units of computer programming in their first year as a prerequisite for acceptance. (Social Science Course students are also encouraged to take computer programming as an elective.) The math includes calculus, ordinary differential equations, linear algebra, complex variables, vector analysis, and various topics in applied mathematics; the computer is not used in any way. On the other hand, the computer programming class requires cadets to make intensive use of the computer (using Hitachi's version of FORTRAN 77) to complete programming exercises on sorting, roots of polynomials, matrix calculations, numerical integration, solution of ordinary differential equations, computer graphics (both display and plotter).

In the second term of their third year, all E.E. students take one 2-unit elective course. About half of them choose Communication Engineering I, a quarter choose Electrical Machines, and a quarter choose Information and Computer Science I. The content of the Information and Computer Science course varies considerably with the professor who teaches it (as is the case with all higher level Electrical Engineering courses at the Academy), but it typically includes Boolean algebra, computer languages (such as PASCAL), numerical analysis, simulation, and computer systems theory (i.e., computer operating systems, etc.). In their fourth year, Electrical Engineering students who have taken this course can elect to take Information and Computer Science II, which typically includes automata theory and formal logic, compiler and operating systems design, simulation, information retrieval, list processing, and data communication.

There is also a "condensed" version of Information and Computer Science I and II combined which can be taken as an elective by other E.E. students during the second term of their fourth year. For other majors, the Electrical Engineering Department offers a 2-unit fourth-year elective on Computer Technology. The course typically includes assembler language, Boolean algebra, logic and sequential circuits, computer arithmetic, and microcomputer architectures.

At the postgraduate level, students specializing in Electronic Computation are required to take two units of Computer Theory, 1.5 units of Computer Theory Exercise, and one unit of Electronics Laboratory in each of the two terms of their first year. Again the course content varies with the professor, but a recent offering of these courses included assembler language programming, computability theory, and logic design.

Postgraduate students in Electronic Engineering may also take as electives 2-unit courses in Software Engineering I and II during their first and second years, respectively. Topics covered in Software Engineering I include data structures and data bases, sorting, files, recursive calculations, and dynamic data structures. Software Engineering II includes language structures, problem-oriented languages, machine languages, system optimization, and various applications. Computer science topics are not included in the required courses for students specializing in Communications Theory, but logic and sequential circuits are covered in the programs on Electronic Circuits and Solid State Electronics.

The senior Electrical Engineering Department faculty in computer science are Professor Toyomi Ohta, who holds the chair in Electronic Computation, and Professor Yoshiaki Koga, who holds the chair in Communication Theory. Professor Ohta's specialty is actually automatic control, so Professor Koga (who worked on the development of ILLIAC IV at the University of Illinois) teaches most of the "mainstream" computer science material such as Software Engineering.

Computer-related research facilities in the department consist of the usual complement of microcomputers, many of which are interconnected as part of an ongoing research project in distributed processing and fault-tolerant networks.

CONCLUSION

The Japanese National Defense Academy attempts to provide its graduates with education and training on a par with that available at the best Japanese civilian universities. Despite the necessary military orientation, cadets at the Academy are encouraged to broaden themselves culturally; extracurricular activities include not only judo, kendo (Japanese fencing), karate, rugby, soccer, American football, swimming,

shooting, and mountaineering, but also clubs focusing on philosophy, social sciences, foreign languages, English speaking, music, drama, movies and photography, flower arrangement, and the Japanese tea ceremony. The aims of Academy education and training, as stated in descriptive brochures, include mention of "a broad mental vision," "a logical and scientific way of thinking together with rich humanity," "a self-disciplinary spirit and noble character," and realization of "the importance of mutual understanding and cooperation," but the most succinct statement of the Academy's philosophy of education is: "A gentleman first, then a military man with a scientific background."

TABLE I

Program	Subject	Number of Units	
		Engineering Course	Social Science Course
General Education	Humanities	14	12
	Social Sciences	14	14
	Natural Sciences	15	18
Foreign Languages	English, German, French, Russian, or Chinese	8 (1 subject)	12 (2 subjects)
Physical Education	Theory, Practice	9	9
Defense Sciences		30	30

TABLE II

Electronic Engineering

Signal Transmission
Communications Theory
Electronic Circuits
Electronic Materials
Electronic Computation
Microwaves
Precision Measurements
Space Communications

Aerospace Engineering

Aerospace Vehicle Dynamics
High Speed Aerodynamics
Propulsion Engineering
Guidance and Control
Servomechanisms
Helicopter Engineering I
Helicopter Engineering II

Materials Engineering

Rocket Propellants
Explosives
Fuels
Organic Materials
Radiation Measurements

Operations Research

Operations Analysis
Applied Probability
Systems Engineering
Planning and Control

Mechanical Engineering

Material Science of Iron and Steel
Prime Movers
Automatic Control
Precision Mechanics
Land Vehicles
Naval Hydrodynamics
Ship Structure and Design
Strength and Fracture of Materials
Machining and Forming

Geoscientific Engineering

Structural Engineering
Structural Dynamics
Soils Engineering
Meteorology
Aerology
Ocean Engineering

Applied Physics

Solid State Electronics
Underwater Acoustics
Ballistics and Fire Control
Applied Electromagnetics
Materials Science
Combustion Science

CARBON RESEARCH AND DEVELOPMENT IN JAPAN

Jack L. White

INTRODUCTION

Japanese activity in carbon research and development is particularly impressive in three areas: carbonization chemistry, graphite intercalation compounds, and carbon fibers. Progress in the first two areas is well documented by publications and conference presentations.[1-3] As shown by Figure 1, Japan also enjoys a predominant world position in carbon fibers, apparently built on technical understanding of the polyacrylonitrile (PAN) fiber that is precursor to the majority of commercial carbon fibers used today; proprietary considerations restrict publication in the area of fiber processing.

This report tends to focus on carbonization chemistry and the more recently developed mesophase carbon fibers, which stem from understanding the role of the liquid crystalline mesophase in determining the morphology of carbon materials. It is based on attendance at three Japanese conferences[1,2] in late 1982, discussions with Japanese scientists, and a review of Japanese contributions to the recent American conference on carbon.[3] The extensive efforts in Japan on carbonization chemistry and on carbon fibers spun from mesophase pitch appear to be motivated by the higher added values that can be derived from the byproducts of petroleum refining and coal coking. Although only a few commercial products have emerged thus far, the basic groundwork appears to be in progress for further dominance of the manufacture of high-grade carbon fiber.

Although carbon materials have played key roles in many of our earliest technologies (e.g., steelmaking) as well as our most commonplace instruments (e.g., the pencil), their use in such current and potential "high technologies" as spacecraft, rocket engines, carbon wire, heart valves, and prosthetic joints seem to be only vaguely recognized outside the immediate technical community. Since most carbon materials are produced ultimately from petroleum and coal tar pitches, they offer extreme examples of higher added value products, and it is not surprising to find that carbon technology is very much alive and growing in Japan.

Although the impressions discussed here were formed within limitations of time and number of contacts, they are consistent in reflecting solid work, aggressively pursued and supported, and directed to well-defined goals with clear practical benefits to the Japanese economy. Three of the meetings are well-documented by volumes of proceedings or extended abstracts,[1-3] and the two major Japanese meetings have been reviewed by Dr. Jim Zimmer,[4] Dr. Michael J. Koczak,[5] and Dr. K. K. Chawla.[6]

Carbonization chemistry is central to the fabrication of carbon products because the structure of most carbon materials is determined by the paths of aromatic polymerization followed during pyrolysis of the organic precursors. Most cokes and graphites form via a liquid crystalline state known as the carbonaceous mesophase, which appears in the final stages of liquid phase pyrolysis. The microstructures imposed by deformation of the viscous mesophase, as in the spinning of mesophase carbon fiber, are frozen into place as the mesophase hardens and are retained with little modification throughout subsequent heat treatments; thermally activated structural adjustments are sufficient to convert mesophase-based carbons to graphitic microstructures. Other carbons, such as carbon fibers manufactured by the carbonization of polyacrylonitrile (PAN) fibers, follow different reaction sequences to produce structures that are not thermally graphitizable. However, in both cases, the properties of the final carbon products depend very sensitively on the morphologies of the aromatic carbon layers established in the early chemical stages of carbonization.

SYMPOSIUM ON CARBON

The International Symposium on Carbon, held in Toyohashi on 1-4 November 1982, was subtitled, "New Processing and New Applications."[1,3,4] This was the second symposium on carbon held in Japan (the first was held in 1964); it was organized by the Carbon Society of Japan and sponsored by twelve Japanese technical societies. The highlights described below are referenced by page number to the volume of extended abstracts.[1]

- Keynote Lecture

The symposium was opened by a plenary lecture by Professor Otani on the "Development of Carbon Technology in Japan," (p. 1). Focusing primarily on developments within the last decade, Otani perceived two primary practical motivations in Japanese research and development: improved needle coke for graphites more resistant to thermal shock, and carbon fibers for the reinforcement of metals and plastics. Concerning research in carbonization chemistry, he feels that the recent recognition by Japanese workers (e.g., p. 172, 153) of the role of hydrogen transfer reactions will prove to be a major step in learning how to control the formation of microstructure in such varied materials as coke, graphite, and carbon fiber spun from mesophase pitch. Otani noted that Japanese workers played key roles in the invention of three types of carbon fibers, including PAN-based fibers, pitch-based fibers (both spun as pitch and as mesophase), and vapor-grown fibers. In regard to mesophase carbon fibers, Otani anticipates an ultimate price of 2000 to 4000 yen/kg ($4 to $8/lb) and strength levels of 5 GPa (700 kpsi). He also directed attention to other significant achievements, e.g., the use of intercalated graphite (graphite fluorides) in high-energy-density lithium batteries (p. 481, 485), and the development of dental implants with fibrous carbon surfaces (about 1 mm in depth) that allow the formation of interwoven collagen-carbon regions between bone and carbon implant (p. 100,103).

-Carbonization and Mesophase Chemistry

A number of Japanese groups are actively exploring carbonization chemistry with the objectives of controlling mesophase morphologies in coke products or finding improved mesophase pitches for fiber spinning.

Several papers were concerned with the role of hydrogen transfer reactions in affecting the viscosity of the mesophase and the microstructure of coke. The transferable hydrogen is measured by copyrolyzing the pitch with anthracene and using NMR techniques to determine the amount of 9,10-dihydroanthracene formed. Obara *et al.* (p. 172) found that strong Lewis acid catalysts (e.g., $AlCl_3$) are effective in increasing hydrogen transfer and decreasing hydrogen gas evolution during pyrolysis; they infer that increased hydrogen transfer lowers mesophase viscosity and permits the formation of the deformed microstructures thought to be desirable in needle cokes. Yokono *et al.* (p. 176) used NMR and ESR to characterize the mesophase-forming behavior of petroleum feedstock blends. In some cases, the blends depart from additivity in respect to electron spin concentration and NMR parameters; the transferable hydrogen also maximizes at such points. Yamada *et al.* (p. 135) found that mesophase pitches formed from acenaphthylene could be hydrogenated by lithium-reduction methods to produce isotropic pitches with good solubility in quinoline. Mochida *et al.* (p. 153) employed hot stage and conventional thermal treatment methods to study the pyrolysis behavior of partially hydrogenated pyrenes. Hydrogenation increased the pyrolysis yield and reduced the apparent viscosity; appreciable fractions of mesophase pyrolyzed to 500°C were soluble in quinoline.

Ota, a key worker in the Japanese invention of mesophase carbon fiber,[7] described molten salt reaction technics that Otani's group uses to explore carbonization reactions (p. 333); these solvent media enable reactions to proceed at 300°C or less. Ouchi (p. 329) compared thermal decomposition reactions in coal tar and petroleum pitches. Solvent fractionation techniques were used to analyze the pyrolysis residues; only modest pressures are required to increase residue yields by retaining volatile fractions in the condensed state until they polymerize. Park *et al.* (p. 123) explored various pitch distillates as solvents for mesophase produced during the pyrolytic distillation of the original pitch starting materials; in general, distillates with good hydrogen donor ability were better solvents, and the mesophase was selectively dissolved to leave a network structure.

The principal American contributions in the area of carbonization chemistry came from Diefendorf's group at the Rensselaer Polytechnic Institute. Viewing the mesophase as a crystal in which positional order is lost more easily than orientational order, they seek basic insights into the conditions for mesophase formation by studies of the parapolyphenylene series (p. 46); the liquid crystalline state is stable when the number of benzene rings exceeds four. Their other contributions were concerned with the pyrolysis behavior of pitch fractions (p. 42) to learn the conditions for formation of "instant" mesophase (instant mesophase is the key concept of the Exxon patent[8] on mesophase carbon fiber) and with methods for measurement of molecular weight distributions in aromatic systems (p. 69).

- Formation of Microstructure in Graphitic Materials

Several papers brought out significant points relevant to the role of the mesophase in determining the microstructure of graphitic products. Shiraishi *et al.* (p. 127) made a detailed study of mesophase spherules by transmission electron microscopy; the results show that sharp curvatures in the mesophase layers near the poles of the spherule affect the layer orientation at interfaces. Romovacek (p. 38) presented evidence that the gas carbon insolubles in coal tar pitch prevent the formation of good coke or graphite by inhibiting mesophase coalescence. Marsh (p. 49) made the suggestion that the strength of a binder-filler artifact may be better understood as interlocking achieved by mesophase solidified in the rough reentrant surfaces of adjoining filler particles. Zimmer (p. 131) presented the first clear evidence of the role of mesophase disclinations in determining the fracture behavior of graphitic materials.

Many workers (e.g., Romovacek and Mochida, mentioned above) are now using hot stage microscopic techniques to obtain qualitative indications of how mesophase microstructures form in the pyrolysis of various precursors. Fitzer and Holley (p. 144) presented observations on mesophase prepared by pyrolysis of acenaphthylene and other pure organic compounds.

- Coke

Processes for the production of needle coke have been pursued with two objectives:

- to find substitute materials for petroleum-based needle coke, and
- to manufacture graphites with greater resistance to thermal shock.

Three papers (p. 5, 534, 553) described the preparation of needle cokes from coal tar pitch by removing the insoluble gas-carbon particles (formed by gas phase pyrolysis of the tar during the initial coal coking). This process, presented jointly by workers from the

Mitsubishi Chemical Industries and Nittetsu Chemical Industrial Company (p. 5), was a warded the 1981 Chemical Technology Prize of the Chemical Society of Japan. Certain common solvents (e.g., kerosene) added to coal tar pitch cause the insoluble particles to coagulate to fast-settling agglomerates that are readily separated from the pitch. Another approach was described by Yudate, Fukuda, *et al.* (p. 111, 115), who examined a series of solvent-refined coals and found that the microstructures of the cokes, as well as the thermal expansivities of graphitized bodies made from the cokes, varied with the extraction solvent and the nature of the coal.

Kakuta (p. 527) presented a poster paper on a petroleum-based coke that differs from conventional needle coke in having a very coarse microstructure but a lower thermal expansion. This adds to the growing evidence that a needle-like structure is not a necessary condition for low thermal expansion, but rather a signal of some other more basic property, perhaps mesophase viscosity, that relates to the thermal expansion of the coke particle.

Three papers (p. 65, 17, 168) were concerned with the preparation of improved blast furnace cokes by pitch additions to coals otherwise unsuitable for this purpose.

- Carbon Fibers

Singer, of Union Carbide, presented a plenary lecture (p. 400) on mesophase carbon fibers. His views were optimistic in predicting further improvements in properties and reduced costs. The special advantages of mesophase carbon fibers were pointed out for:

- reinforcement of structural elements requiring high stiffness, and
- electrical conductors, as intercalated "carbon wire."

Several papers were concerned with surface treatment of carbon fiber to achieve good adhesion with polymer matrices. Cziollek *et al.* (p. 280) subjected high modulus PAN-based fiber (Sigrifil HM) to three oxidation methods and compared the strengths of unidirectional epoxy matrix composites. Despite some degradation in filament strength, all methods led to much stronger composites; wet oxidation was the most effective. Yamamoto (p. 292) conducted a similar study with PAN-based fiber from Tokai Carbon (Thermolon S-T and S-M); the strengthening effects were less than observed by Cziollek *et al.*, but still substantial. In this case, electrolytic polishing appeared to be the most effective surface treatment.

Another approach to improved composite properties is whiskerization of the fibers by vapor-growth methods. Katsuki *et al.* (p. 493) showed that dense whisker arrays, with whiskers of the order of 1.0 μm diameter, can be grown on various fiber substrates by catalyzed deposition from benzene. This development seems to be in an early stage; no composites were shown or described.

Three papers were presented on vapor-grown carbon fibers. Endo (p. 515) described how fine fibers of controlled diameter (less than 0.1 μm) can be grown from benzene vapor by controlling the particle size of the iron or iron-nickel catalyst. The method appears well-suited to harvest fibers in volume. In another paper (p. 212), Endo described how resistivities approaching that of copper can be achieved in this fiber by intercalating materials such as AsF_5 or HNO_3. Egoshira (p. 317) described how similar fibers can be prepared from sulfur-bearing compounds; in this case, thick (10 to 30 μm diameter) and straight filaments can also be obtained by controlling the deposition conditions.

Four papers were concerned with the oxidation process used in the stabilization of PAN-based carbon fibers. Fitzer *et al.* (p. 284, 288) showed that the carbonization yield is primarily determined by oxygen uptake, that the extent of oxidation must be limited to attain maximum strength, and that oxidation with linear heating rate offers advantages over isothermal processes. Yokota, Takahagi, *et al.* (p. 300, 321), from Toray Industries, used advanced spectroscopic techniques to define the oxygen-bearing chemical structures developed in stabilization.

Several papers were concerned with SiC fibers. Dohi, from Tokai Carbon (p. 547), described discontinuous Tokamax fibers, 0.1 to 0.5 μm diameter continuous fiber spun from polycarbosilane and heat treated to form SiC; these are marketed as Nicalcon fibers. The oxidation process used to stabilize the spun fiber can be varied to a trade-off between strength and modulus in the finished fibers.

Two studies of mechanical properties included high modulus mesophase carbon fibers in their test series. Sawada and Shindo (p. 296) found that the torsional modulus and strength of mesophase fiber are substantially less than those of PAN-based fibers; the fracture surfaces of mesophase fibers reveal extensive layer wrinkling. DaSilva and Johnson (p. 304) used a knot test (from textile technology) to evaluate the flexural properties of PAN-based and mesophase fibers; the high modulus PAN-based and mesophase fibers were found to be more brittle and inflexible than lower modulus PAN-based fibers.

- New Carbon Materials

Four papers were concerned with graphites manufactured from green coke or from mesophase at controlled levels of heat treatment. Ogawa *et al.* (p. 9), in sintering raw coke particles (~ 5 μm), found improved strength in the graphitized compacts if the coke particles were subjected to quinoline extraction. Murata (p. 534) of Mitsubishi Chemical Industries, reported on a graphite fabricated from a pitch-treated green coke; the density is 1.845 g/cm^3, and the bend strength is 105 MPa (~ 15 kpsi). Aoki (p. 542), of Tohoku Kyowa Carbon Company, described Metaphite, a graphite prepared by sintering a powder prepared from a mesophase pitch; this material is made in both graphitic and nongraphitic grades. The graphitic grade is available with density as high as 2 g/cm^3 and bend strengths of ~ 100 MPa (~ 14 kpsi). Sato (p. 268) reported on the mechanical properties of the Metaphite materials.

Matsumoto (p. 531), of the Toyo Tanso Company, demonstrated an isotropic graphite (ISEM-4) that can now be made in blocks of about 0.7 m^3; the bend strength is 45 MPa (~ 7 kpsi). Yamamoto (p. 538), described a series of graphites manufactured to achieve specified levels of linear thermal expansion (from 1 to 15 x 10^{-6} K^{-1}).

Dohi, (p. 546), of Tokai Carbon Company, described progress in making large plates of glassy carbon, reaching 0.7 m^2 in a plate 2 mm thick.

Three papers (p. 84, 88, 418) concerned carbon-carbon composites. Yasuda (p. 418) described friction and wear tests on aircraft brake shoes; the temperature rises sufficiently (~ 900°C) to cause appreciable loss by oxidation. A paper on alumina-graphite refractories (p. 196) is also of interest because improvements in thermal shock resistance were sought by modifying the binder pitch with phenol resin additives. A maximum in the energy for fracture was found at a pitch/resin ratio near 2; the coke microstructure formed at this ratio was fine isotropic.

- Nuclear Graphites

Several Japanese groups remain active in nuclear graphites. Three papers (p. 204, 240, 244) were concerned with clear definitions of the effects of oxidation (e.g., by impurities in reactor coolant gases) on the strength and other properties of structural graphites.

- Graphite Intercalation Compounds

Eager interest and activity in graphite intercalation compounds flourishes in Japan as in Western countries. The Toyohashi symposium included in this category two plenary lectures (p. 309, 427), four invited papers, and a dozen contributed papers. Furthermore, there was a special one-day meeting devoted to this topic after the regular symposium was completed.

- Literature Center, Carbon Society of Japan

The Japanese have felt an urgent need to collect literature on carbon from the present wide array of journals in which it is published and to make the information readily available to their research and development people. A "literature center on carbon" was established at the Toyohashi University of Technology in 1976 for this purpose. An appeal was made by this literature center for all carbon authors to contribute preprints, reports, theses, and reprints; contributions will be announced in *TANSO*, the journal of the Carbon Society of Japan, and authors will be sent annual lists, in English, of the accumulated materials. The address is:

The Literature Center
The Carbon Society of Japan
c/o Professor M. Inagaki
School of Materials Science
Toyohashi University of Technology
Tempaku-cho, Toyohashi 440, Japan

KYUSHU POSTSYMPOSIUM ON CARBON

A postsymposium on carbon was held on Kyushu, the westernmost of the principal islands of Japan, on 9-11 November 1982, at the Kuju Lakeside Hotel. This meeting was chaired by Professor I. Mochida of the Research Institute of Industrial Science, Kyushu University. The purpose was to review seven selected topical areas and to discuss significant points from the symposium on carbon before a largely Kyushu audience, many of which had not attended the Toyohashi meeting.

The topics are listed in Table 1. The atmosphere was that of an academic seminar. Most speakers presented extended reviews of their contributions to the Toyohashi symposium. Singer included discussion of an ESR study on mesophase carbon fibers, and Fitzer's hour included a videotape presentation of hot stage work on mesophase formation. Mrozowski brought out the close relationship between coalification mechanisms, operating on a geological time-scale, and the carbonization mechanisms operative in such processes as coking.

One evening was devoted to a poster session, which permitted Japanese workers to present their work under favorable conditions for discussion. A student of Mochida

demonstrated a videotape of mesophase behavior observed by hot stage microscopy of a hydrogenated pitch. This pitch had been so well stabilized by a controlled level of hydrogenation that observations could be made on a pool over 5 mm in depth; such a stable and fluid mesophase pitch could be a prime candidate for fiber spinning with minimal bubble formation.

The concept of a postsymposium can be recommended for consideration by American technical societies as a means of digesting the enormous amount of material presented at annual conferences. The concept worked well at Kuju despite the obvious language problems, as well as the proprietary limitations on data exchange.

FOURTH INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS[5]

This meeting, designated as ICCM-IV, was held in Tokyo on 25-28 October 1982. Entitled "Progress in Science and Engineering of Composites," this was the fourth in a series of international meetings begun in 1975. It was organized by an ad hoc committee chaired by Professor Emeritus T. Hayashi of the University of Tokyo. Practical support was provided by three Japanese government agencies, including the Ministry of International Trade and Industry (MITI). The proceedings were assembled in two large volumes;[2] in general, complete papers, rather than extended abstracts, were published. As pointed out by Koczak[5] and Chawla,[6] the conference emphasis was more toward design application and less toward fibers and resin systems. The discussion below is limited to papers concerned with carbon fibers and is referenced by page number in the conference proceedings.[2]

- Plenary Lectures

The remarks by Professor Hayashi in his keynote lecture on "Composites in Japan" (p. 1) offered an enlightening illustration of government-industry cooperation as practiced in Japan. A national research and development project on composites was established by MITI in 1981, and six basic areas of development were recognized:

- high-performance ceramics,
- synthetic membranes for new separation technology,
- synthetic metals,
- high-performance plastics,
- advanced alloys with controlled crystalline structures, and
- advanced composite materials.

The working group on advanced composite materials, chaired by Professor Hayashi, adopted two specific goals:

. Materials	. Tensile Strength
fiber-reinforced plastic	2.4 GPa (350 kpsi) at 250°C
fiber-reinforced metal	1.5 GPa (220 kpsi) at 450°C

These materials are intended primarily for aerospace and automotive applications; the time-scale for these goals is eight years.

The perspectives for the production of reinforcing fibers were presented by M. Tatsuhana, of Toray Industries (Japan's largest producer of carbon fiber), in a plenary lecture entitled, "ACM Reinforcement Fiber Production and Its Application in Japan,"

(p. 75). Although aramid and SiC fibers were discussed, the emphasis was on PAN-based carbon fiber. While playing a less active role in developing applications, Japan has dominated production of carbon fiber through a basic understanding of how to produce the optimum precursors. The point is illustrated by the experience of Nippon Carbon, who first commercialized PAN-based carbon fiber. However, Nippon Carbon depended on others for precursors and thus lost most of the market when the textile manufacturers that produce the PAN fibers entered the field; the production of PAN-based carbon fiber is now dominated by Toray and Toho Beslon. Tatsuhana also documented current rapid growth of Japanese capacity for fiber production as well as the dependence of U. S. producers on Japanese suppliers for precursors. If the trends implied by Tatsuhana continue, the Japanese dominance of carbon fiber production must be expected to increase.

Tatsuhana indicated that pitch-based fibers (both varieties, i.e., low modulus fiber spun from pitch and high modulus fiber spun from mesophase pitch) constitute less than 10% of the 1981 carbon fiber market. However, he drew attention to the substantial potential market for pitch fiber, e.g., for concrete reinforcement and the replacement of asbestos, and to the extensive developmental activity in Japan on mesophase carbon fiber (discussed further below).

- Contributed Papers on Carbon Fibers

Oberlin (p. 91) described recent progress in understanding the structure of PAN-based carbon fiber by transmission electron microscopy. The results emphasize the wrinkled and corrugated layers; the model proposed by Oberlin is interesting for its disclinations as well as the lenticular pore structures. Diefendorf (p. 97) reported on the strength and microstructure of PAN-based carbon fiber (Hercules HMS). By the use of controlled microetching techniques to mill away the periphery of a filament, the modulus was observed to decrease by a factor of 5 from rim to center. The rim is therefore under a compressive stress of about one-third GPa (~ 50 kpsi), which may be expected to contribute to the tensile performance while inducing premature buckling failure in flexural loading. The optical response of the carbon fiber is due to the inherent preferred orientation, not to the internal stress. Piggott (p. 193) reviewed the critical role of fiber matrix interface mechanisms in determining the mechanical properties of fiber-reinforced composites.

SIXTEENTH BIENNIAL CONFERENCE ON CARBON

The Sixteenth Biennial Conference on Carbon was held on 18-22 July 1983 in San Diego. Japanese workers contributed 30 papers and constituted the largest group of overseas attendees (27% of total overseas attendees). The papers surveyed below are referenced by page numbers in the volume of extended abstracts.[3]

There were 12 Japanese contributions in the fields of carbonization chemistry, mesophase behavior and structure, and applications to various types of coke. The papers by Mochida and co-workers were basic in nature, but directed to practical applications; four of these were concerned with the development of improved mesophase pitches for fiber spinning. The chemical approaches included pitch fractionation (p. 96), exploration of hydrogenation and oxidation techniques to improve anisotropy and yield (p. 14), and cocarbonization with hydrogenated additives (p. 32, 94). Various types of pitch were found to respond very differently to the Chwastiak process[9] for the preparation of spinnable pitches.

Takashima *et al.* (p. 78) explored various precursors to which hot stage microscopy can be applied to observe mesophase formation. Vaporization can pose serious problems for some materials, e.g., a coal tar pitch, and the technique as currently used is probably limited to qualitative observations of mesophase behavior. Yamada *et al.* (p. 82) measured the preferred orientation of magnetically oriented mesophase; the molecular alignment was stronger in mesophase derived from petroleum pitch than in mesophase from acenaphthylene.

Kakuta (p. 591) reported on chemical and structural changes during the heat treatment of premium grade petroleum cokes. Mochida *et al.* (p. 576) demonstrated the roles of preliminary thermal treatment and reflux during coking in achieving high density in coke. Fukuda (p. 62) reported on the preparation of needle cokes from solvent-refined coal; tetraline-derived cokes displayed stronger needle-like textures and lower thermal expansivities.

The technique of growing carbon fibers from benzene vapor was described by Endo (p. 523), who was also involved in collaborative studies of the structure (p. 219) and intercalation characteristics (p. 271, 272) of these fibers. This work, originally begun at Shinshu University with T. Koyama, has now stimulated much work on intercalation and the mechanisms of fiber growth (e.g., p. 521, 523, 527, 529, 533). Tibbetts (p. 531) described an alternative preparation technique in which the fibers are grown from natural gas; strength and modulus values as high as 360 kpsi and 65 Mpsi, respectively, were measured on single filaments.

In summary, the contributions to the Sixteenth Conference on Carbon indicate that Japanese groups are maintaining substantial efforts on carbon research, with particular strength in intercalation compounds and carbonization chemistry. A point of future interest is the possible emergence of vapor-grown carbon fibers made from inexpensive precursors as high modulus reinforcement fibers as well as intercalation media.

DISCUSSION

The vigor of Japanese research in such areas as intercalation compounds and carbonization mesophase chemistry was clear in the number and quality of papers presented at the Toyohashi symposium and the San Diego conference. Evidence of activity on carbon fiber was more subtle; however, many Japanese attendees at the technical meetings were prepared to discuss this subject, and further information came from industrial visits (in assessing this activity, I was joined by J. E. Zimmer, whom I thank for discussion and criticism).

The production of PAN-based fiber is now dominated by chemical manufacturers that produce acrylic fibers for textile applications. Premium grade fiber of high strength appears to depend on precursor preparation, and the methods of precursor production are considered proprietary. Accordingly, little information is published on the processing of PAN-based carbon fiber, and announcements of progress in the production of improved fibers are usually made by the marketing arms of the manufacturing firms.

In regard to pitch-based carbon fibers, it should first be noted that the Kureha Chemical Company has been producing fibers spun from pitch for over a decade; these fibers are weak but cheap, and of low modulus, and should not be confused with the high modulus carbon fiber spun from mesophase pitch. A number of Japanese firms appear to be actively engaged in research and development on mesophase-based carbon fiber. A partial list compiled through discussion with Japanese workers includes:

Asahi Chemical
Dainippon Ink and Chemical
Idemitsu Petrochemical
Kawasaki Steel
Kureha Chemical
Mitsubishi Chemical Industries
Mitsui Petrochemical Industries
Nippon Carbon
Nippon Kokan
Nippon Oil
Nippon Steel
Sumitomo Metal
Tonen Oil
Toray Industries

As of this writing, we know of no mesophase carbon fibers of Japanese manufacture that are commercially available, although some Japanese workers appear to have experimental samples for study. It remains to be seen how many mesophase-based high modulus carbon fibers will be commercialized to compete with the Union Carbide fibers that have been on the market since 1976.

It is difficult to rationalize conflicting elements of cooperation and competition that appear in the Japanese efforts on carbon fiber. Perhaps the key lies in the activities of the Ministry of International Trade and Industry (MITI), who encouraged the formation of the Japanese Carbon Manufacturers Association. One purpose of this organization is to standardize the methods of testing carbon fibers to permit direct comparisons of fiber quality. A report[10] summarizing test methods adopted to data has been published.

We were surprised by the frankness and candor of Japanese workers and organizations in discussing their work in the development of carbon fibers. Their motivation in the development of mesophase carbon fibers seems to come directly from the national drive to find higher added value products to manufacture from existing byproduct refinery streams or from coal tar pitch. One organization anticipates that mesophase carbon fiber equivalent to PAN-based fiber can be produced at one-half to two-thirds the cost. The goals undertaken for their mesophase fiber are tensile strength of 3 GPa (430 kpsi), freedom from handling damage, elongation to break of 2%, and surface treatments to assure matrix adhesion as good as that shown by PAN-based fiber. Our attention was also drawn to a recent development by Yamada at a government industrial research institute in Kyushu; a hydrogenated "premesophase pitch" is spun at high speed to produce a fiber that can be heat treated under tension to attain properties competitive with conventional mesophase carbon fibers.

The strong market position of Japanese producers of carbon fiber, illustrated by Figure 1, has been built over more than a decade, and the steady improvements in fiber strength imply that these are achieved on a sound technical basis. The extensive published research in carbonization chemistry and the innovative activity in mesophase-based fiber and other products suggests that the essential technical background is being put in place for further dominance of the market for high modulus as well as high strength carbon fibers.

REFERENCES

1. "New Processing and New Applications," *International Symposium on Carbon, Extended Abstracts,* proceedings of symposium held at Toyohashi on 1-4 November 1982, organized by the Carbon Society of Japan, distributed by Kagaku Gijutsu-sha, Daiichi Kanamori Building, 1-5-31 Yushima, Bunkyo-ku, Tokyo 113, Japan.

2. *Progress in Science and Engineering of Composites,* edited by T. Hayashi, K. Kawata, and S. Umekawa, two volumes, proceedings of the Fourth International Conference on Composite Materials held at Tokyo on 25-28 October 1982, available from Japan Society for Composite Materials, c/o Business Center for Academic Studies, 2-4-6, Yayoi, Bunkyo-ku, Tokyo 113, Japan or from the Metallurgical Society of AIME, P. O. Box 340, 420 Commonwealth Drive, Warrendale, PA 15086.

3. *Extended Abstracts,* Sixteenth Biennial Conference on Carbon, proceedings of conference held at San Diego on 18-22 July 1983, sponsored by the American Carbon Society.

4. "International Conference on Carbon," J. E. Zimmer. *ONR Far East Scientific Bulletin, 8* (1), 67 (1983).

5. "Fourth International Conference on Composite Materials (ICCM-IV)," M. J. Koczak. *Ibid.,* p. 38.

6. "Composite Materials: Some Recent Developments," K. K. Chawla. *J. Metals 35* (3), 82 (1983).

7. "Carbonaceous Mesophase and Carbon Fibers," S. Otani. *Mol. Cryst., Liq. Cryst. 63,* 249 (1981).

8. "Forming Optically Anisotropic Pitches," R. J. Diefendorf and D. M. Riggs. U. S. Patent 4,208,267 (17 June 1980).

9. "Low Molecular Weight Mesophase Pitch," S. Chwastiak. U.S. Patent 4,209,500 (24 June 1980).

10. "Standardization of the Testing Methods for Carbon Fibers," Technical Committee, Japan Carbon Fiber Manufacturers' Association (September 1982).

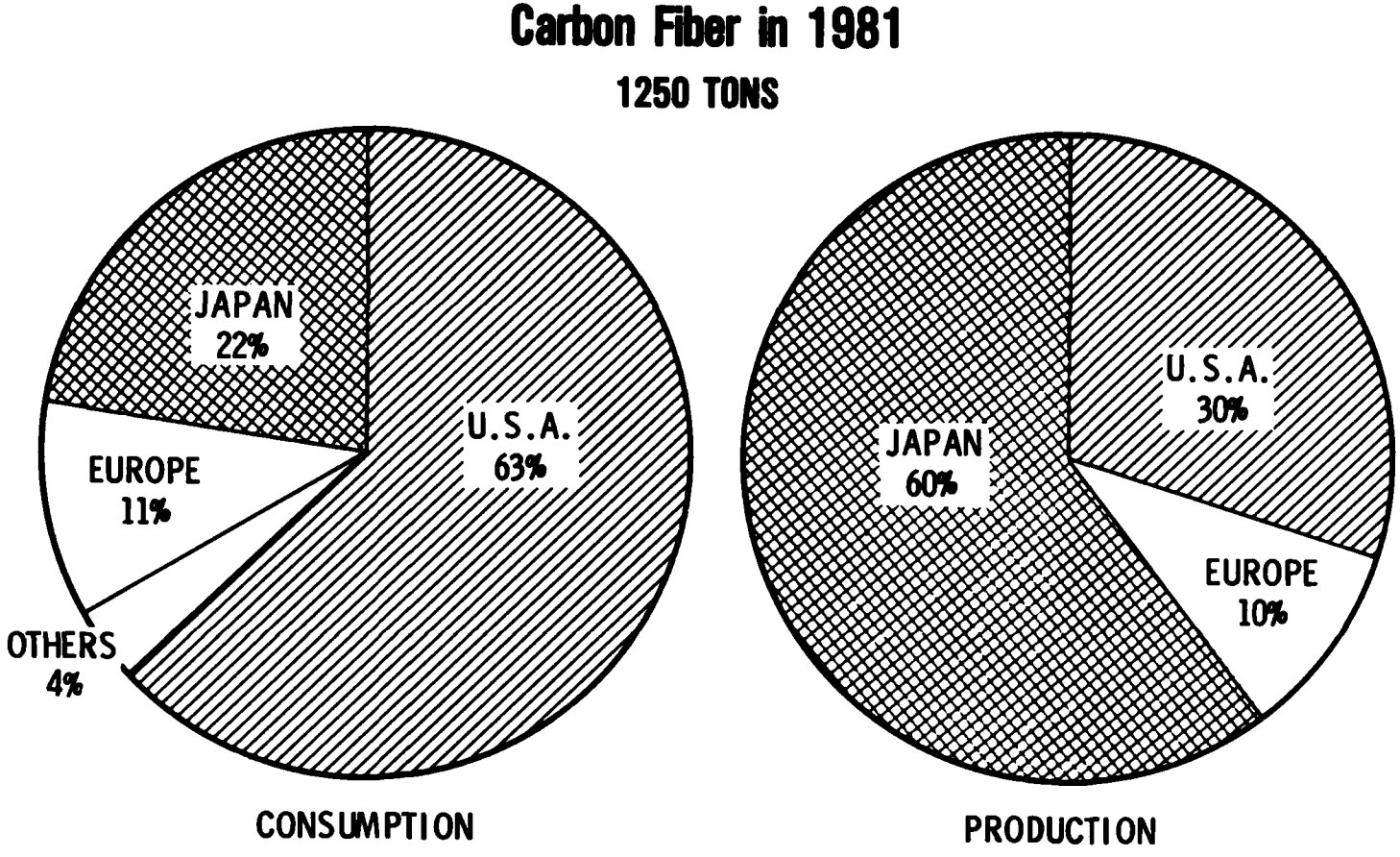


Figure 1. World Demand and Supply of Carbon Fiber in 1981; from Tatsuhana. (Reference 1, p. 79).

TABLE I

Topics Discussed at Kyushu Postsymposium on Carbon

Speaker and Affiliation	Topic
J. B. Donnet University of Mulhouse, France	Surface energy of carbon
J. L. White The Aerospace Corporation, U.S.A.	What is mesophase?
H. Marsh University of Newcastle Upon Tyne, U.K.	Control of mesophase
L. S. Singer Union Carbide Corporation, U.S.A.	Production of carbon fiber
E. Fitzer University of Karlsruhe, West Germany	Property and application of carbon fiber
S. Mrozowski Ball State University, U.S.A.	Carbonization and coalification
D. D. Whitehurst Mobil Research and Development, U.S.A.	Regressive reactions which occur during coal liquefaction

INTERNATIONAL SYMPOSIUM ON SOLID STATE PHYSICS UNDER PRESSURE: A REVIEW

Earl F. Skelton

INTRODUCTION

An international symposium was held 18-21 January 1984 in Izu-Nagaoka, Japan, about 100 km southwest of Tokyo. The conference was convened to honor Professor Shigeru Minomura of the Institute for Solid State Physics (ISSP), University of Tokyo. Having reached his 60th birthday, the mandatory retirement age at the University of Tokyo, Professor Minomura will be vacating his laboratory at ISSP. (He has, however, accepted a professorship in the Department of Physics, University of Hokkaido, where the mandatory retirement age is 63.)

The conference was sponsored jointly by the Physical Society of Japan, the Chemical Society of Japan, the Japanese Society of Nontraditional Technology, and the Japan High Pressure Institute, organized under the auspices of the Science and Technology Agency and the Agency of Industrial Science and Technology, Ministry of International Trade and Industry. The symposium was also held as a regional meeting of AIRAPT, the International Association for the Advancement of High Pressure Science and Technology. Participation at the conference was by invitation of the organizing committee; of the 81 attending conferees, 58 were from Japan, 14 from the United States, three each from China and West Germany, two from France, and one from the Soviet Union.

The format of the conference was to hold oral sessions in the mornings and afternoons and poster sessions in the evenings. There were generally lively discussions following each paper. Sixty-three research papers were presented; these were divided into seven topical categories:

- superconductivity,
- synchrotron radiation,
- ultrahigh pressure techniques,
- crystalline structure,
- noncrystalline materials,
- optical, and
- magnetic properties.

OPENING SESSION

The conference was opened by several renown speakers and old friends of Professor Minomura offering plaudits on this special occasion; speakers were Dr. Takeshi Kanazawa of the Japanese High Pressure Institute; Professor Shinroku Saito of the Technological University of Nagoya; Professor Jiro Osugi, the most famous high pressure researcher in Japan and retired professor of Kyoto University; and Professor Syuniti Akimoto, a long-time colleague of Professor Minomura at ISSP.

The opening lecture was delivered by Professor Harry G. Drickamer of the University of Illinois, one of the most outstanding men in the field and the first recipient of AIRAPT's "Percy Bridgman Award." In reviewing noteworthy accomplishments in high pressure science over the past 30 years, Drickamer felt that there were four areas where significant achievements had been realized:

- equation-of-state calculations,
- structural phase transitions,
- dense fluids relaxation and kinetics, and
- electronic processes,

the last topic being the subject of his lecture: "Pressure Tuning of Electronic Energy Levels."

In his presentation, Drickamer reviewed the fundamental effect which pressure has on the electronic energy states of solids and, through that, on their physical and chemical properties. Since these phenomena are related to the electron arrangements in the ground state and to the characteristics and energies of the various excited states, these properties have definite spatial character and can therefore be altered through compression, hence "pressure tuning." Drickamer went on to offer examples in three different categories of electronic tuning:

- characterization of electronic energy states,
- tests of theoretical calculations, and
- new induced ground state transitions.

The second keynote speaker was Dr. Francis P. Bundy of the General Electric Research and Development Center. Bundy is known as one of the fathers of the synthetic diamond as he was a principal member of the team which, in the late fifties, succeeded in developing a process for the commercial conversion of graphite into diamond. He reviewed the current status of the pressure-temperature phase diagram of carbon and pointed out the fact that today's best theoretical calculations indicate that the diamond-cubic phase should be stable to pressures in excess of 20 Mbar.

SUPERCONDUCTIVITY

Much interest in this and other sessions was focused on 'black phosphorus,' an element which undergoes a series of interesting pressure-induced phase transitions: at 4-to-8 GPa, it transforms from its normal orthorhombic phase to a rhombedral structure, and above 10 GPa the rhombedral phase converts into a simple cubic structure. Concomitant with these phase transitions are changes in the electrical properties, from a narrow band gap semiconduction, to semimetallic, to metallic. Of even greater interest, however, is the pressure dependence of the superconducting transition temperature, T_c, presumably of the metallic phase. A Japanese group reported different temperature dependencies for T_c, depending on the manner of cooling and pressurization, in the extreme rising from 5 to 14 K as the pressure was increased to 30 GPa. A group from West Germany showed a T_c versus pressure curve with considerable structure having a local minimum and two local maxima.

Clearly much additional research, including low temperature, high pressure structural studies, will be needed to clarify much of the superconducting properties of black phosphorus. Excitonic superconductivity was suggested as one possible explanation; it was also noted that this may be the first example of a simple cubic metal. Five separate papers were given in this subject:

- Kawamura *et al.*, National Research Institute for Metals (Japan),
- Wittig, Institut für Festkorperforschung (West Germany),
- Kikegawa and Iwasaki, The Research Institute for Iron, Steel, and Other Metals (Japan),
- Shirotani *et al.*, Muroran Institute for Technology (Japan),
- Morita and Asahima, Tohoku University (Japan).

SYNCHROTRON RADIATION

One of the newest developments in the field of high pressure research is the performance of experiments with the extremely brilliant synchrotron radiation sources. In the first of two sessions on this topic, the overall status was reviewed in a paper by Skelton *et al.* of the U.S. Naval Research Laboratory. This was followed with details of a number of structural studies pursued at the Cornell High Energy Synchrotron Source (CHESS) by Bassett *et al.* of Cornell University; at the Stanford Synchrotron Radiation Laboraotry (SSRL) by Manghnani *et al.* of the University of Hawaii; at the Japanese Photon Factory (PF) by Hamaya *et al.* of Osaka University; by Yagi *et al.* of ISSP, and by Tsuji, also of ISSP.

The most exciting paper in this area, however, was that given by Shimomura *et al.* of the Japanese National Institute for Research in Inorganic Materials (NIRIM). In this, details were given of the most advanced high pressure system operating on a synchrotron beamline: MAX-80, a 500-ton multianvil press with large volume pressure/temperature capabilities to 8 GPa/1700 C or 13 GPa/600 C. In a separate paper by Yamaoka *et al.*, also of NIRIM, one of the first studies performed in MAX-80 was reviewed, viz., the first *in situ* structural observation of the conversion reaction of graphite into diamond. (This author had the unique opportunity to spend the week following the conference performing experiments on MAX-80. Details of that experience will be given in an article to be published in the next issue of the *ONR FE Scientific Bulletin*.)

ULTRAHIGH PRESSURE TECHNIQUES

Perhaps one of the most exciting papers at the conference was that presented by Mao of the Carnegie Institute of Washington. He offered preliminary evidence of a new high pressure record. In recent efforts to exceed his presently held static limit of 1.72 Mbar, he used a modified diamond-anvil design and did surpass the old record. Unfortunately this achievement is tainted by the fact that above 1.84 Mbar, the ruby fluorescence radiation, which has been used for many years as a pressure calibrant, becomes unreadable. Therefore Mao had to extrapolate from 1.84 Mbar in order to determine the cell pressure; based on this he estimated a value between 2.5 and 2.6 Mbar, well above the previous record. Future work in this area will probably have to return to appropriate equation-of-state values for determination of the pressure.

CONCLUSION

There is insufficient time in this limited review to capture all of the excitement and to highlight all of the quality work which was presented at this symposium. The written manuscripts of each of the papers were collected at the beginning of the conference and reviewed by selected referees during the meeting. Because of this efficient treatment, it is expected that the proceedings will be published and available by midsummer 1984.

As a worker in this field for more than 15 years, this author has attended many regional and international meetings on high pressure. This indeed was one of the best in terms of the quality of work presented, the formal and informal discussions held, and the overall arrangements. All of this is due to the tireless efforts of the organizing committee composed largely of Professor Minomura's past students. Thus, the overwhelming success of this conference, just as many of the major advances in this field, are to be credited to the person for whom the symposium was convened, Professor Shigeru Minonura.

HUMAN FACTORS IN ADVANCED DISPLAYS

Nicholas A. Bond, Jr.

INTRODUCTION

Display design is another one of those fields that has developed since World War II. Prior to that time, there were practically no courses and specialists in displays. Instrument and aircraft engineers produced displays which seemed to work well enough for their special needs. The field was quite conservative, as a glance at automobile and power plant displays over a span of prewar years will show. There were a few controversies, to be sure, such as whether the aircraft or the horizon should move on a dynamic aircraft panel indicator; but these were confined to a small coterie of interested people and manufacturers. Often, the solution to a display design problem was obvious, or appeared to be so; as late as the 1960s, many process control and power generating plants had large walls full of dials, meters, and continuous recorders. When new machinery or processes were added to a given installation, you just added more gauges and dials to the wall. Presumably, experience in monitoring a large panel of displays would eventually produce acceptable performance: an experienced person will know what to watch, and what to ignore.

Several technologies changed the display game. The first of these was the cathode ray tube which suddenly offered the potential for presenting large quantities of information. This device opened up tremendous new possiblities and questions for the display designers. Shortly thereafter, small computers with rapid computational power enlarged further the array of opportunities; by 1960, for instance, it was feasible to study the basic features of the pilot's world outside the cockpit and to depict key geographical and terrain features on a computer-driven CRT in an aircraft (Roscoe, 1980). Recently plasma vacuum fluorescent, electroluminescent, and liquid crystal techniques have extended the physical possibilities of displaying and updating information. It is fair to say that most of the R&D effort in the display domain still goes toward physical, engineering, and economic aspects; everybody wants more brightness and color saturation, faster response, lower power consumption, higher resolution, and lower cost. Also desirable are thinner and lighter display panels, along with a reduced quantity of high voltage drivers in the control circuitry. Despite the enormous R&D investments all over the world, many physical problems remain so intractable that, when cost is a factor, the display standard is often still either the commercial TV tube with 500 or so lines, or a standard computer terminal which can depict a few hundred or a few thousand alphameric characters by dot matrix techniques.

THIRD INTERNATIONAL DISPLAY RESEARCH CONFERENCE

Alongside all the physics and engineering efforts the human factors community has been plugging away at some of the persistent problems such as what information really needs to be displayed, how it can be assimilated and acted upon by a human operator, what the human information load limits are, and so forth. The recent Third International Display Research Conference at Kobe, Japan (3-5 October 1983) was a good place to observe display state-of-the-art in Asia. Since the first international conference was held in Munich, the meeting sites are being rotated between the U.S.A., Europe, and Japan. At Kobe, a majority of the human factors papers were from Japanese scientists.

- University of Tsukuba

K. Hiwatashi (Institute of Information Sciences, University of Tsukuba, Ibaraki) emphasized three critical factors in providing an effective pictorial display:

- appropriate optical viewing conditions (contrast, brightness, resolution, etc.),
- subjective evaluation of the picture (permissible noise and distortion, trade-offs in color brilliance and "reality", etc.),
- cognitive factors (utilization of items of information, tolerable error behaviors, etc.).

Hiwatashi's research program proceeds from the traditional three-stage hierarchical model of human reception of information: sensation, perception, and cognition. Some of the most intriguing and the most difficult problems, of course, may be found in the cognitive stage, which is dependent upon and loosely correlated with the two earlier stages. Sometimes separate systems are more or less discernible across the stages; for instance, recent Japanese physiological work with monkeys (Iwai, 1981) has suggested that there are two visual systems, a new system which is concerned with the perception and meaning of a recently learned pattern and an old system which involves the basic perception and cognition of space. These separate systems can even be located physiologically with some precision: the posterior inferotemporal area appears to be a main site for visual perception while the anterior inferotemporal cortex is the principal area where cognitive integration is achieved.

In a couple of ingenious experiments at Tsukuba, Hiwatashi was able to separate perceptual and cognitive elements in a pattern judgment task. His experimental materials were displays of real Kanji, or Chinese characters, and bogus Kanji-like figures. A foreigner without any knowledge of oriental languages would not be able to tell the difference between the two types of symbolic displays if the technical information content distributed in the lines and strokes was reasonably similar. But by using Japanese subjects, who could read Kanji, the impact of cognitive factors could be estimated. The experimenter began the judgment series with short (80 ms) and slightly defocused stimuli, gradually lengthening and clearing the displayed material. The subject had to identify and read the Kanji being shown, or else to copy the bogus Kanji on a response sheet.

As shown in Figures 1 and 2, plots of acuity and exposure time against complexity of stimulus pattern (as expressed in number of Kanji lines), show that the cognitive judgments are remarkably stable across complexity. Once a real Kanji can be marginally, but correctly, identified no improvement in viewing conditions is of much benefit to the viewer. On the other hand, nonmeaningful Kanji-like stimulus figures need more time and more resolution to be appreciated and reported, and the required time goes up with complexity.

A second experimental setup at Tsukuba observed the eye movements of subjects and scored them according to stationary fixation time, T, and movement distance, N, between fixation points. These parameters proved to be quite informative. For example, changing the size of projected letters on a display screen did not produce changes in either T or N, as long as the number of letters stayed the same. But if a mixture of Kanji and hiragana (Japanese syllabary) symbols were presented, N values were observed to decrease systematically. Meaningless sentence mixtures of Kanji and hiragana produce still smaller N movements. Such findings indicate top-down processing by the human subject, and they were confirmed further when subjects had to look at the display through a small window. This restriction of vision so reduced the effectiveness of cognitive factors that responses began to resemble those with bogus stimuli. Such demonstrations show that useful trials of cognitive processing can be performed on standard computer terminal displays, and they also indicate how cognitive and perceptual elements can be segregated.

- NHK Broadcasting Science Research Laboratories

At the NHK Broadcasting Science Research Laboratories in Tokyo, S. Nagata has been systematizing the cues for depth perception. The principal depth cues themselves are well-known, of course; binocular parallax and convergence, monocular motion parallax, particle density distribution on surfaces, brightness gradients, atmospheric alteration, color distance effects, and so on. What is original about the NHK research is the attempt to evaluate the impact of the separate cues on a common scale of measurement. In the NHK framework, depth sensitivity was defined as the ratio $D/\Delta D$ of the viewing distance D to the threshold of detection of depth difference, ΔD. The operational definition of parallax and other cues was accomplished within the setup depicted in Figure 3.

- Discussion

For the psychophysical judgments the observer would see a fixed black rod, R_f and two other movable black rods, RM_1, and RM_2, in front of a white background screen. One of the movable rods, say RM_1, would be controllable by the human observer. By means of an external control system, the subject would adjust RM_1 until the perceived depth difference between RM_1 and the standard rod R_f was the same as some preestablished depth difference betwen R_f and RM_2. Given the geometry of the setup and a fixed distance between the two eyes, various indexes of depth sensitivity were defined. For instance, as indicated in the upper right hand part of Figure 3, the effectiveness of shape or slant cues could also be evaluated for a standard surface. Even such indicators as atmospheric attenuation or air perspective were also formulated by manipulating the contrast in an exponential fashion. Dynamic thresholds for monocular motion parallax estimated the speed at which subjects could detect a change in the apparent depth (under a variety of conditions, the optimum velocity was about 6-8° degrees of arc per second).

Some results are shown on the log-log plot of Figure 4. Binocular parallax is clearly the most effective depth cue at viewing distances up to a few meters. Convergence enhances depth if there is a sufficient difference in visual angle between the views received by the two eyes (that is, when the object is very close). Beyond a few meters, however, the effectiveness of this cue drops to zero. Thus, this cue vanishes. Although the curves for convergence and accommodation resemble those for binocular parallax, the impact ratio is some orders of magnitude less. Atmospheric cueing does not enhance depth perception until the viewed object is about 90 meters or more away. From that point, it increases linearly for a few kilometers, and then drops as acuity limits are reached. Brightness and texture have their most significant effects at medium distances, and in fact, for viewing points a few dozen or few hundred meters away, they may be the most effective of realism cues (which is one reason why the movie and TV industry goes to such great trouble to film on location instead of using toy superimposed backgrounds).

The binocular parallax cue, then, is the predominant one at short viewing distances. A next question addressed by the NHK investigators was whether the combination of other cues, such as changing object size with binocular parallax would intensify depth (produce a smaller sensitivity threshold). The experimental vehicle for this work was the NHK Versatile Stereo Display which permitted dynamic control of binocular parallax and size, and also allowed the subject to set those conditions that gave equal depth perceptions as the image was varied or shimmered steroscopically. In Figure 5, which summarizes one set of viewing conditions (oscillation frequency of 1 Hz, 30:1 luminance ratio, 1.35 m viewing distance), there are clearly some regular relations and trade offs between size change and stereo-parallax change, and when both cues are presented together the total effect is more powerful than simple addition would indicate.

Besides the compelling result that binocular parallax is so strong a cue up to a distance of a few meters, the NHK team also concludes that motion parallax is an effective cue, and that it may depend on optimum stimulus velocity. Also, the rather flat effectiveness ratios for pictorial brightness and for texture imply that clearly presented information on shade, gloss, and textural detail can enhance the viewing experience. To the practical display engineer, some of the implications of these findings are already known: realistic displays should be wide-angle, in high resolution, and at some distance from the viewer. In fact, among the most realistic displays that now exist are those at Disneyworld-EPCOT and other places where the viewer is nearly surrounded by a fine-grained and dynamic picture.

A pastime of a century ago was the viewing of pictures through a reflectoscope, wherein the viewer looked at a landscape or other scenes via a concave mirror or a convex lens. Many observers reported real depth effects from this display, and some writers have postulated that the depth came from inadvertent binocular parallax caused by lens or mirror defects. The NHK results, however, tend to refute the binocular disparity explanation. If the reflectoscope (called nozoki-karakuri in Japanese) got its image realism from the binocular cues received, then the disparities should increase from the median line of the picture, and so the perceived depth of part of a scene would depend on where that scene was in the total display. Actually the depth depends somewhat on the objects appearing in the picture and it can be experienced with monocular viewing. In all probability, then, the nozoki-karakuri simply reproduced pictorial cues fairly well.

Cognitive aspects of at least some standard scenes probably could be investigated by the NHK psychophysical matching approach. The present remarkable capabilities of high-resolution video presentation, and the control possibilities for laboratory work should facilitate better displays in the near future. One of the areas that seems to call for psychophysical work is the rapid learning of dynamic cue relationships. Again, looking at one of the Disneyworld rides, a strong and perhaps pleasantly stressful experience is gained when sitting in a slowly moving car. Alongside the track a projected forest scene accompanies the car for a few feet. It was originally at about the same velocity as the slowly moving car. The passenger quickly learns this: the car moves with the scenery. However, within a short time the velocity of the projected scene accelerates while the car, though still moving, stays at the same velocity. Perceptually, the observer feels himself to be moving very fast, and the effect is robust enough to produce quite high speed reactions when the scenery swerves around a (nonveridical) high-speed curve. While the ride designers clearly were able to set their display parameters close enough to optimum levels to provide an amusing ride experience, and instant relief at the end, far from enough is known about the learning (and forgetting) of such stimulus relations.

Also performed at NHK laboratories was a series of studies on the eye fatigue of subjects who read TV screen displays. The practical background of this work is the anticipated application of teletext screens in homes, schools, and offices. The concept of the home information system, for instance, is now being pursued in several Japanese companies and segments of it are already being tested on a small scale. While there are several ways of classifying such systems, it appears technically feasible right now to provide bidirectional teletext, bidirectional ATV instruction, multiplexed character broadcast reception, and a whole array of financial and accounting services to the home. One system concept, shown in Figure 6, has about half a dozen video, audio, and data signal inputs with the main display being a high-resolution TV screen. Needless to say, this truly interactive TV will be radically different from the present commercial

receiver; at the minimum, planners are saying, there will be provision for image and voice input from two or three systems, image output, synchronized voice and other audio multiplexing, and various filter functions. NHK's experimental media TV, for instance, has more than 20 pins on its terminal, and according to reports it is fully controllable by a special computer. There seem to be no insuperable barriers to the receipt and control or recording of all the information.

All these capabilities will surely be utilized in some way or another as they become widely available. But system designers will need reliable data on human responses to the information presented. Already there is some informal reaction to VDT terminals in office machines, and there is reason to believe that present commercial displays are not optimal. The NHK program has been examining both the subjective and objective evaluation of practical video screen conditions. Among their studies was a questionnaire survey of people who regularly work on terminals.

The NHK subjective evaluation questionaire had two parts: the first part asked about "your physical condition now." Subjects could rate on a four-point scale, ten items such as "are your eyes tired," and so forth. After an actual session at the terminal six further questions were answered, as shown in Figure 7.

Under continual or high load use one would assume the visual system degrades and so various objective measures of eye fatigue were taken to complement the subjective judgments. After some pretesting, seven indexes were finally selected as being suitable: critical flicker frequency (CFF), acuity (equivalent to the standard Bausch and Lomb test), accommodation near point, accommodation time, numerical error checking (equivalent to Minnesota Clerical Test), holding time (interval between initial focusing and blurring of an object 30 cm from the eyes), and a perception involving the threshold for seeing contrast on a dynamic grating. Decrement or simple difference scores were accumulated on each of these measures, and it was assumed that any observed decrements were mainly due to fatigue of the peripheral visual system; subjective changes, on the other hand, were regarded as being more related to the integrative functions of the central nervous system. A variety of luminance ratios, color arrangements, and character sizes were used to explore the idea that optimum viewing conditions might be more or less discernible during the experiment.

The task demands during screen presentation were quite demanding. In one part of the experiment, the subjects had to read characters on 50 pages of screen text in 40 minutes. A time line for one part of the experiment appears in Figure 8. That basic schedule was repeated 16 times, once for each presentation mode. Distributions of subjective and objective measures often appeared to be rather skewed, but all dimensions of the data seemed to show satisfactory variances among individual subjects.

With such a large experiment, it is impossible to condense the results into a few succinct statements. It did appear, however, that physical and subjective scores were related quite strongly, as seen in Figure 9. In fact, a simple Pearson correlation between the two types of scores would yield a (deceptively) high coefficient because the effects of the best and worst conditions were so marked.

Steady visual work at the screen does bring physical decrements in several of the performance indexes. A look at the contrast sensitivity changes across time is often quite clear-cut; an illustration, taken from one subject, appears in Figure 10. The worst condition (low luminance for this particular subject) is visibly different from better screen modes and it seems likely that, with much longer viewing times, the decrements

would increase. There are many apparent interactions such as the fact that some viewing situations produce distinctive decrement and recovery curves. As the data in Figure 10 suggest, rest period or recovery times of a few minutes can have a strong compensatory or remediation impact. There are even hints that strenuous visual work, followed by a resting interval can bring performance up to higher-than-baseline levels. In general, though, many of the trends, apparent from such individual graphs as Figure 10, did not stand up as statistically significant over the whole subject cohort. Rather surprisingly, there were no strong overall differences among the 16 presentation modes.

Organizing the mass of data into good and bad presentations, the good aspects tend to be:

- ordinary TV program content,
- high luminance,
- blue characters on white background,
- medium contrast,
- yellow characters on blue background,
- large characters,
- no line flicker.

On the other hand, the bad modes seemed to have:

- reverse contrast, or low contrast,
- green characters on cyan ground,
- red characters on blue ground,
- scroll (horizontal one-line presentation.)

One implication of these experiments is that it will take even tighter comparisons than those done at NHK in order to demonstrate conclusive physical superiority of anyone mode or set of modes. Therefore, subjective evaluations often can be the major criteria for selecting and setting up an interactive system, given today's video tubes and luminances. Perhaps system designers should allow the users to set up many of their own preferences regarding viewing modes.

Refreshing of physical performace parameters could often be done by means of a short break, according to the results. Regrettably there are very few VDT studies that carry refresh data across really long periods of activity, or that investigate differences in cognitive requirements such as those that exist between letter correction and complex editing of text. Ergonomic methods for making such determinations seems to be adequate, however, and the field should see many more evaluation studies as advanced systems get closer to application. Parenthetically, the Japanese electronics industry is well aware of the introductory problems with the PRESTEL system in Europe, and in all likelihood any Japanese system that is offered internationally will not be just a slightly updated PRESTEL copy. Many Japanese planners seem to believe that the best strategy is to introduce a fairly comprehensive total system with many inputs and with real interaction; the inaugural date for such systems will be 1986-1988 at the earliest. [British television viewers can now purchase TELETEXT and PRESTEL services. TELETEXT users can buy a TV set which gives one-way access to several data banks: financial news, spot road and weather conditions, games subtitles for the deaf, and so forth. The TELETEXT rental cost is low, on the order of the price of a daily newspaper; nearly a million British homes use the service. PRESTEL operates over phone lines and is much more expensive, but customers can also feed information into the data banks, perform a limited amount of searching, and thus achieve some interaction with the

system. According to reports, PRESTEL users often have difficulty with present indexing systems, and spend their on-line time trying to find out just what to call. Nottingham Building Society (equivalent to a U.S. savings and loan company) is now using PRESTEL as an experiment in home banking; customers can transfer funds, pay bills, and even ask for loans.]

Some Japanese researchers are concerned with the health aspects of video display terminals (VDTs). In Japan, as elsewhere, there are frequent complaints from operators of eye strain, backache, and general tension from VDT work. A few researchers have even claimed that cataracts can be caused by continued VDT exposure, and there are famous trials and expert testimonials in the domain. A Canadian employees union official noted that ". . . all of these cataracts were diagnosed as occurring on the posterior portion of the lens capsule, a sign of radiant energy damage. The victims were too young to have developed common aging cataracts." But Johns Hopkins ophthalmologists and an NIOSH task force too, dismissed such reports (Mauk, 1984).

VDT'S emit x-ray and gamma radiation in detectable but probably negligible amounts; some studies also have picked up very low frequency radiation in the 15-20 kHz range. Very long wave radiation can be found too, but again the indications are that the levels are extremely low.

The ionic conditions prevailing near a VDT vary with humidity and other ambient conditions; but there are strong tendencies for negative ions to accumulate near the VDT screen and thus the area where the operator sits can become a zone that is depleted of negative ions. Since this depletion can have metabolic and other biological effects, work is continuing on the evaluation of the human hazards involved. There are commercial devices which allegedly improve the ionic states in a VDT office environment, but again the evidence is unconvincing. It is uncertain to what extent they reliably produce a negative-ion-rich environment, and nobody is sure about the effects on practical work output. A team at the University of Occupational and *Environmental* Health in Fukuoka has been doing work on the effects of VDT work on eye accommodation performance. (Kurimoto *et al.* 1983). At Kobe, they described some trials with operations in three age groups. Since Japan's proportion of aged persons is increasing steadily, there are many practical queries, such as whether older people can work well at terminals for long periods. If so, then perhaps the aged could do much of the VDT work required in the information society.

A simple name-search task was employed for some exploratory runs. Subjects scanned lists of countries, flowers, and animals for certain target items; when a target was found, a key push was made. This rather boring search job continued for two hours. Katakana (Japanese syllabary) characters were employed. Along with the usual performance measures, there was also an infrared optometer reading on the low frequency component (LFC) of visual accommodation (earlier Japanese work by Suzumura had suggested that when LFC increased so did perceived visual fatigue). The percentage of LFC was taken as one measure of visual load. A color comparison was made by presenting characters in white for some trials and in green for others. Also, three luminance levels were tried out: 7, 14, and 28 cds/ m^2. Three screen sizes (9, 12, and 14 inches nominal), each with a 6 kHz refresh rate and 741 scanning lines completed the set of independent variables.

Many of the LFC index variances seemed to occur in the first hour or two of intensive visual work, and to adjust rather well after that. A bit of illustrative data may be seen in Figure 11 where it also appears that the LFC response curve to intensive work

is perhaps not very steep. Relatively high luminance produced more LFC activity during the first hour. The LFC peak for 28 cd/m² shown in Figure 12 is nearly twice that for the two lower luminances, but resting recovery was fairly rapid and complete within an hour.

Larger screens favored productivity; Figure 13 suggests that the 14-inch screen not only had a lower visual load on the LFC score, but also resulted in some 10% or more actual finished work. There were also some slight indications that separating the Katakana characters at 35 per line was better than packing them together at 70 per line.

In a way, all these preparatory experiments enabled the Fukuoka workers to optimize the VDT terminal, at least within the off-the-shelf equipment conditions they had available. Once this was done, young, middle, and old workers performed the standard search task. Though the older subjects had slightly higher visual load LFC's, indicating that they might be expending more visual effort, their performance was essentially equivalent to that obtained from the younger workers.

The implications, then, were quite clear: if you are restricted to off-the-shelf equipment then you should use a large display with green colored characters and high luminance in the central display. If you provide these optimal conditions, older people can be satisfactory VDT operators. In other words, provide a good display, and the slight performance decrements due to age will tend to vanish. Engineering psychologists may regard such findings with rather a déjà vu feeling and remember the provision of quickened and predictor displays in the 1960s. That early work showed that if a display is made good enough, say like a quickened driving control display in a submarine, then the task becomes so easy that any person, or indeed a machine such as a simple amplifier, can accomplish the task with near-zero errors.

VDT research is active in many countries, and now that Japan is doing evaluation studies too, we can expect better displays to be commercially available. Long-term VDT studies are certainly in the works, too, along with investigations into the clustering or isolation of VDT workers in offices. One of the informal pressures toward good displays is the increasing proportion of professionals who edit or compose their own material on terminals; clearly, the desire for better terminals by such high status users will facilitate more favorable hardware and more flexible systems.

- The Information Society

More than a decade ago, NHK Broadcasting Science Research Laboratories in Tokyo began to work toward the "Information Society of the Future." An important part of this society, it was postulated, would be the wide availability of high quality television pictures which would be driven from a variety of sources. A preliminary task was the determination of the video display requirements, or at least those parts of the requirements that could readily be foreseen. Most of the preliminary work pointed toward a high-resolution system, with a large size and a wider-than-usual aspect ratio. This was due to the fact that the human observer cannot watch a close, fast moving display for a long time; informal trials showed that about four or five times the picture height is the minimum distance for effective (non fatiguing) viewing.

Experiments on the conditions necessary for reality were done with a concave hemispherical screen (Figure 14). Curves of subjective effect produced by different visual field angles showed that an angle of about 30° began to give an impression of reality, with diminishing returns past that point. When combined with subjective beauty and resolution requirements for a displayed picture, the following hardware specifications were tentatively set:

- picture size of more than a square meter (1.4 m wide by 0.8 m high),
- brightness of at least 30-foot Lamberts,
- resolution of 1125 lines (comparable to 35mm slides and superior to 35mm movie film),
- field refresh frequency 50 Hz,
- zoom up capabilities controlled by the viewer for part of the main display.

In laboratory setups and even in home test trials, NHK has already achieved most of these resolution and brightness requirements using Schmidt or rear projection optical techniques. The best system, though, providing it can be realized, will be a thin panel display, probably of the gas discharge type. (High brightnesses and efficiencies are available right now, albeit in smaller panels than eventually will be required.)

Practical workers in display technology often dismiss the high-resolution television idea. They observe that the present enormous investment in current TV parameters will prevent assimilation of superior systems. They also point out that many homes now prefer to have two or three ordinary TV sets around the house, that "all that quality" of a high-resolution system is not really necessary, and that future systems will have to be an outgrowth of present video industry practices. In contrast, the NHK standpoint is that eventually there will be international TV, that it will be engineered approximately to the high-standards mentioned above (high-resolution, wide aspect, etc.), and that a small stand alone computer will drive each installation. When that comes about, parameter differences such as scanning lines and refresh rates will cease to be obstacles, and the advanced systems will be able to present materials in a whole range of frequencies and repetition rates. The Japanese standpoint is analogous to high fidelity recording: people can detect improvements in audio performance and they are quite willing to pay for them. But older materials, such as classical piano vocal or orchestral performances which were recorded in another time, can still be accommodated within the improved technology. Certainly even a brief look at the large 1125-line Japanese TV display would convince the observer that it is a different experience from the present cheap video box.

- Novel Display Techniques

An intriguing 3-D display concept from France was presented by J. Guichard and A. Poirer (Centre National d'Etudes des Telecommunications, Issy-le-Monlineaux). A lenticular screen was used as an optical separator, and under it was a liquid crystal matrix display. Under appropriate driving from a special computer, the crystals are activated to provide binocular-disparity stimuli to the two eyes, thus resulting in a true depth experience. The system now operates with a 128 x 256 matrix for each eye, and though there is some optical and electrical cross talk, good black-and-white binocular depth is reported without any glasses and in a normally lighted room. Improvements in resolution and cross talk will certainly be sought; but many display researchers should be interested in a true depth lenticular device which does not need glasses or special helmets. It is necessary for the observer's head to be nearly stationary. (Figure 14 gives a plan view of the French system.)

Y. Miyatake and Y. Nagaoka (Matsushita Electric, Kadoma, Osaka) demonstrated their new one-piece wide-angle rear projection screen. The screen was designed to provide good brightness for viewing angles larger than 30° (on ordinary screens, as viewing angle increases, reflection of incident light increases thus weakening the relative strength of video light). A cross section of the (patented) screen is shown on Figure 15, and in Figure 16 a gain curve as function of viewing angle is depicted; it

appears that the losses up to about 50° are quite smooth and noncatastrophic. Matsushita believes that the principles used in the screen can be adapted to higher-resolution video. At the Kobe meeting, the company also presented two papers on high-resolution TV electron guns. Though not strictly within a human factors purview, the steady improvements in such hardware should assist in the trend to more compatible and flexible displays.

In addition to the NHK setup, three Japanese companies (Sony, Ikegami, and Panasonic) are now demonstrating 1125-line systems at technical meetings all over the world. CBS Technology Center (Stamford, Connecticut) has proved that, in principle, a compatible 1050-line high resolution color picture can be transmitted along with a conventional 525-line color picture signal. The 1050 lines are driven by two regular TV channels, with channel 1 delivering >25 lines worth of information to the center area of a 1050-line picture, and channel 2 providing "augmentation" for the remaining areas outside the center. In practice, a special receiver would accept information on both TV channels and put it together so as to realize an apparent 1050-line picture (interpolated information would be used on the 10% or so outside edges, though 1050 actual lines would be drawn). The CBS technology is far enough along for the company to have applied for experimental broadcasting on six 24-MHz channels. Some observers think that the CBS will be the first practical system, and that it will be seen first by American customers in bars and restaurants before being marketed for home use (Jurgen, 1983). Japan seems to be betting that a "real" 1125-line system will be the eventual international choice. Nobody knows how this controversy will turn out as there are tremendous political and financial elements involved.

CONCLUDING COMMENTS

An authoritative American report on the previously mentioned health aspects of VDT exposure has just appeared, and it offers some reassuring conclusions on such drastic risks as cataracts or other eye diseases, pregnancy or births abnormalities, orthopedic conditions, and migraine headaches [National Research Council (NRC), 1983]. Though many such complaints are received, and VDT work station improvements can often be made, a large fraction of the health complaints can be attributed to the nature of the work done at the terminal. Repetitive and boring work, whether at a high-tech terminal or not, is still boring and so the people may be really complaining about the nature of their jobs, maybe using the terminal as a handy focus for expressing their resentment of managerial insensitivity. The NRC review also found that "ionizing radiation" from terminals was not a significant risk, but that issue is still unsettled.

A rather unexpected omission from the Kobe meeting was any major session or papers on video games. If the first major (1973) generation was Pong and the second generation is exemplified by Space Invaders (1978), then one or two other generations are already in sight (Perry, 1983). Dragon's Lair already offers the player a semblance of control, (short sequences are activated according to the player's decisions), though not in the real time Pong sense. The animation graphics are much improved over the rather jumpy, cavorting two-dimensional space vehicles of the late 1970s. A few games are mixing film clips with computer-generated imagery; Astron Belt, which is now being demonstrated at Japanese fairs and expositions, is one of these. Clever matching of hit spots with actual shots from the player produces an explosion on the screen. But even these hybrid capabilities may be outmoded in a few years as computer memory, graphics, and animation all advance in performance and become cheaper. Judging from the Kobe meeting, either the Japanese manufacturers are waiting temporarily to see how the U.S.A. game design battles work out, or else they are keeping their own game secrets

under close wraps. However that may be, there is practically no psychophysics of video games in the scientific literature. Instead, the game industry proceeds in a rather personal and jagged fashion; occasionally a game concept is novel enough and cheap enough to dominate the market, then it is replaced by a new game and perhaps by a new manufacturer. Thus one must admire the rapid response of the industry to new concepts; but perhaps one would also wish that more research knowledge about video games was available.

The cognitive science community often stays away from the ergonomic and data processing requirements of displays. After all, cognitive scientists are more interested in how people structure an interesting problem than they are in how the problem solution might be aided. But several times at the Kobe meetings and in informal discussions, cognitive elements were clearly the central ones and were also the most controversial. Two examples can be mentioned here. One is the usefulness of time series graphics. Many computer and software groups have been working to provide management with good graphics, which certainly means legible plots, charts, and projections and may mean quite complex adjustments and forecasts. Gigantic data bases now can be accessed, and there are packages to facilitate their use. Few actual data exist, however, on the understanding produced by the displayed graphics and images. Does the user really understand all the smoothing and seasonal adjustment techniques employed, does he appreciate the variances around some of the displayed parameters? A beautiful display can be deceptive in its depiction of reality unless it indicates the underlying data limitations. At the same time, it does a user little good to be able to assemble various graphics or images into an overall presentation unless there is at least fairly deep appreciation of how all the stuff appearing on the screen got there.

The situation is somewhat similar in computer-aided display (CAD) and computer-aided manufacturing (CAM) systems. Toyota's approach illustrates some of the problems and possibilities (Toyota Motor Corporation, 1, Toyota-cho, Toyota, Aichi 471, Japan). Suppose you are planning a die-stamping operation for an automobile part. At Toyota, the CAD complex will display for you a 3-D isometric view of the part. It also has stored on its disk memories various subroutines such as those for blank holder surface specifications, draw-stage parameters, tipping of parts during successive stamping operations, and the like. All these analytical capabilities eventually produce a data set which goes to a numerically controlled die-forming facility. Theoretically the dies are produced automatically, or at least semiautomatically. For extremely simple parts everything works well, the dies are made, the parts are produced. But for complex CAD die planning, human intervention is still crucial. An experienced die designer may know that a certain corner area is liable to "pucker" or that a base-to-pillar section length ratio is critical to stamping a large quarter panel. These knowledges would cause an experienced user to compute alternative die-face and drawing schemes. And again, when the alternatives are "played out" by the CAD system, it may take something of an expert to evaluate the results and settle upon a practical scheme for making the part.

In both time-series and CAD/CAM displays, then, the encapsulation of knowledge can be a key issue. Perhaps complex displays will evolve in the direction of "expert systems," which will not only utilize the best available stored knowedge, but will also teach and extend that knowledge as the systems are used. Fortunately, some of the display problems of expert systems can be anticipated right now, and it will be a challenge to the human factors community to provide sound bases for the design of such displays.

REFERENCES

Aviation Psychology, Roscoe, S. N. Iowa State University Press, Ames, Iowa, 1980.

"Model Regarding System of Information Processing in Visual Goal-directed Behavior of Macaque Monkeys," Iwai, E. A. Proceedings of a Symposium on the *Pharmacology of Learning and Memory*, Hakone, Japan, 1981.

"The Problems and Promises of High-definition Television," Jurgen R. K. *IEEE Spectrum, 20*, (12) 46-51 (1983).

"The Radiation Question," Mauk, S. *PC World*, 230-237, January 1984.

"Video Games: The Next Wave," Perry, T. S. *IEEE Spectrum, 20*, (12) 52-59 (1983).

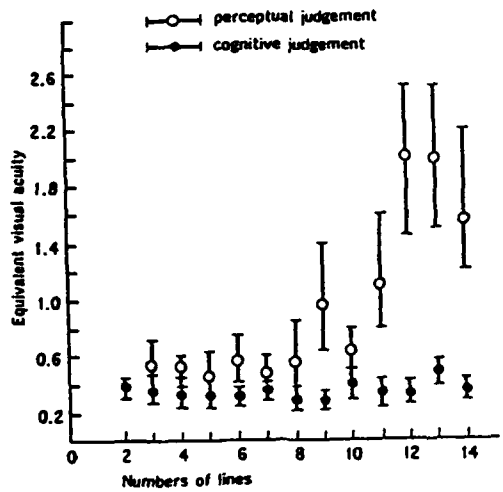


Figure 1. Acuity or Resolution Required to Judge and Reproduce Perceptual (random-line) and Cognitive (Kanji) Figures.

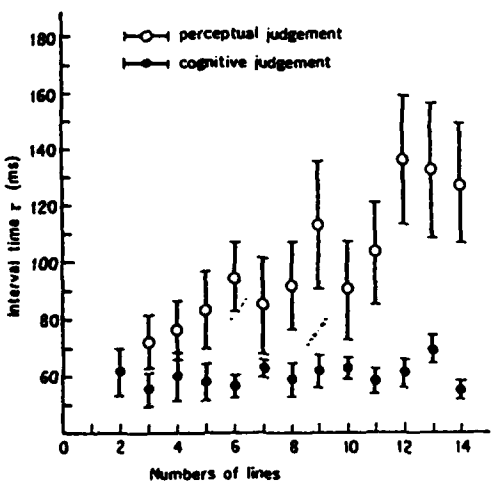
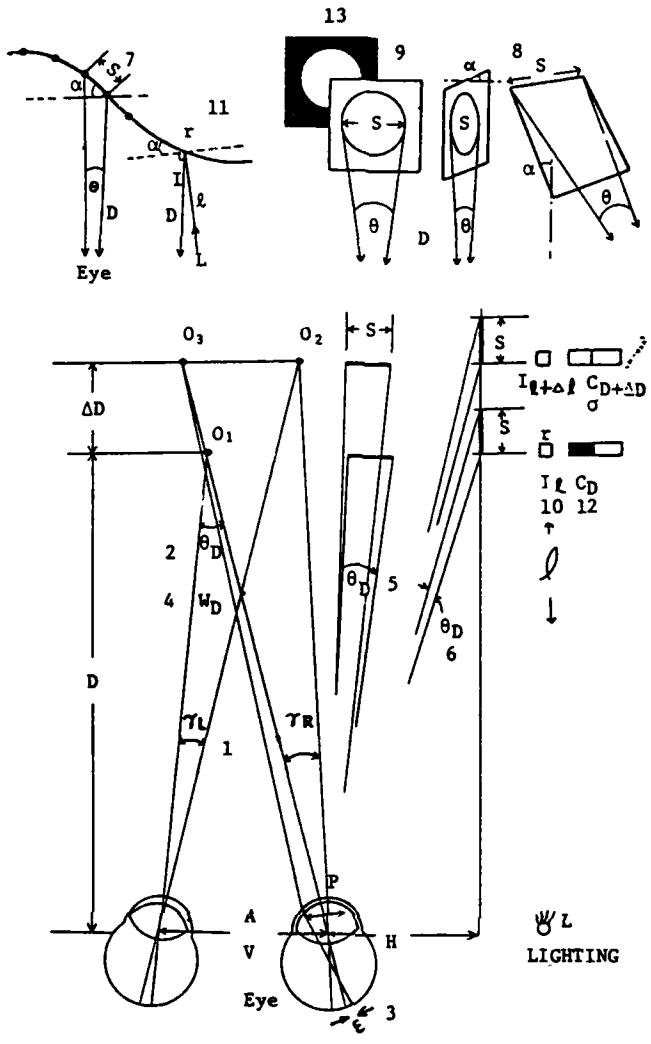


Figure 2. Time Required to Judge and Reproduce Perceptual (random-line) and Cognitive (Kanji) Figures.



1: Binocular parallax $\gamma_L-\gamma_R=\theta_D-\theta_{D+\Delta D}$ at the distance A between pupils

2: Convergence cue $\theta_D-\theta_{D+\Delta D}$

3: Blurring cue ε of accommodation on pupil diameter P

4: Motion parallax $\gamma_L-\gamma_R$ or $\omega_D-\omega_{D+\Delta D}$ at monocular moving vision of distance A or speed V

5: Transversal size cue $\theta_D-\theta_{D+\Delta D}$

6: Longitudinal size cue on depth direction axis at distance H

7: Density cue $(\frac{S}{D}\cos\alpha)^{-1}$ of texture on surface at slant α

8: Shape cue at slant

9: Intersection cue

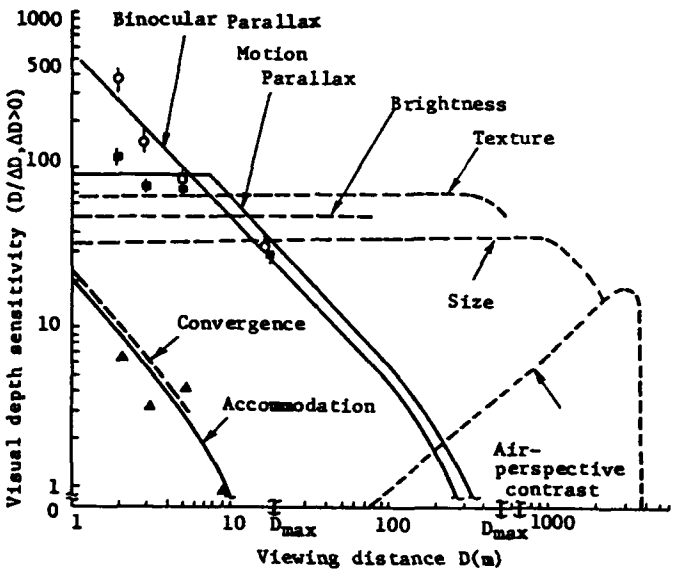
10: Brightness cue $I_\ell-I_{\ell+\Delta\ell}$, $I=\frac{r\cdot L}{\ell^2}$ of the object with refractory factor r at lighting distance ℓ under lighting L

11: Shade cue I·cos α on slanted surface

12: Air-perspective contrast cue $C_D-C_{D+\Delta D}$ of air scattering constant σ

13: Color effect

Figure 3. NHK Setup for Depth Perception Psychophysics



Symbols (●, ■, ▲) indicate the averages of five measurements of subject S.N. and bars on the symbol indicate standard deviations.

Binocular parallax	: A=0.065 m, $\Delta\theta$=25"
Motion parallax	: V_{max}=0.8m/sec, $\Delta\omega$=4'/sec, ω_a=6°/sec
Accommodation	: P=0.005 m of natural pupil, $\Delta\theta_A$=[1/1.2]'
Air-perspective	: C_o=1, σ=1 km, ΔC=11% of C_D [±1 dB], C_{min}=0.02
Transversal size	: $\Delta\theta_s$=2.5% of retinal size θ_s
Texture/longitudinal size	: $\Delta\theta_s$=2.5% of retinal size θ_s
Convergence	: $\Delta\theta_s$= 10 min
Brightness	: I/ΔI=0.02

Figure 4. Depth Sensitivities of Various Cues for One Subject.

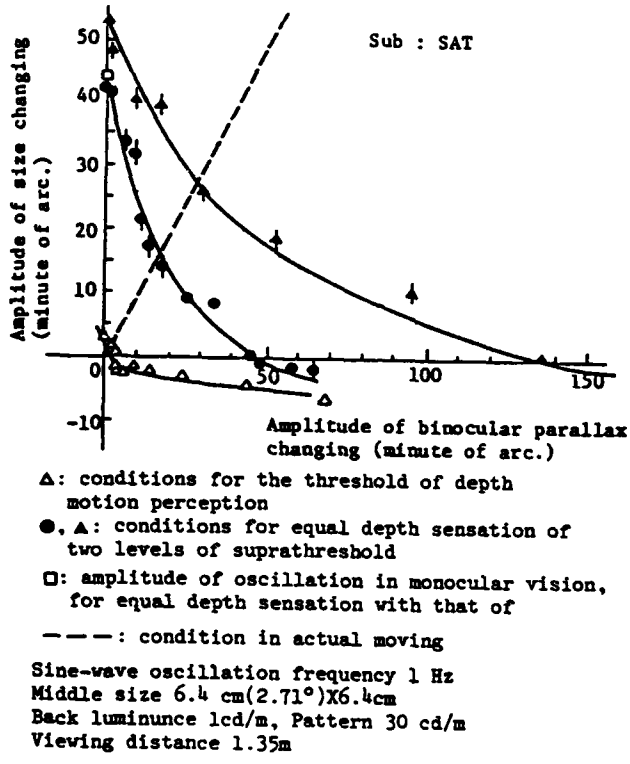


Figure 5. Perceptual Effects from Binocular Parallax and Size Change.

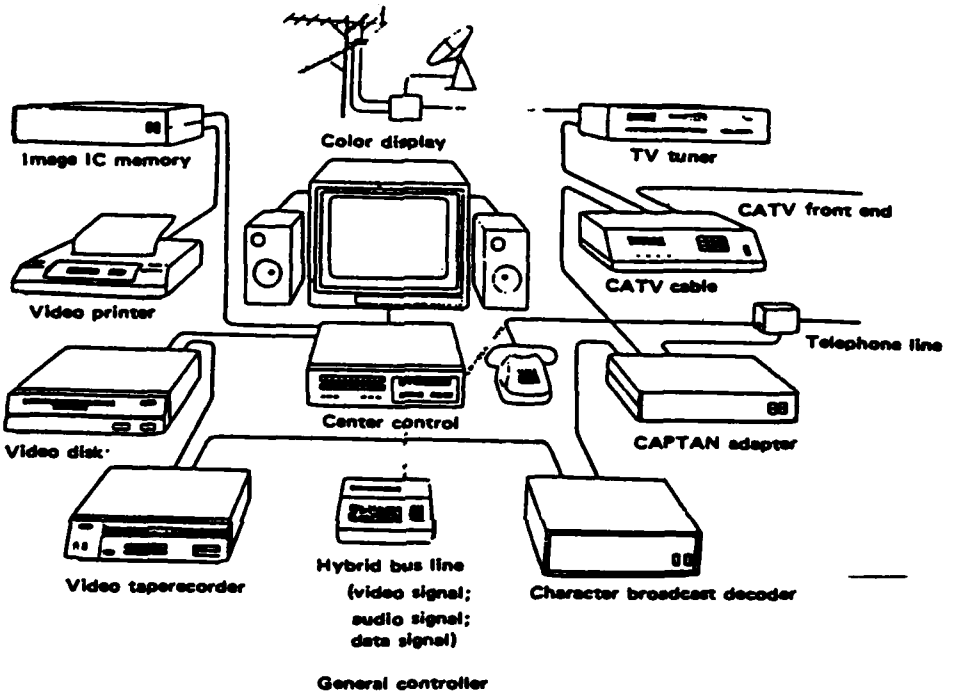


Figure 6. Japanese Home Information System Concept

A. Circle the following that describe your physical conditions now.

	Not at all	Somewhat	Yes	Very
1. Are your eyes tired?				
2. Feeling pain behind your eyes?				
3. Feeling pain around your eyes?				
4. Feeling a dullness around your eyes?				
5. Feeling pressure around your eyes?				
6. Feeling dryness of your eyes?				
7. Feeling dim?				
8. Eyes irritated?				
9. Tearing sensation?				
10. Blinking more frequently?				

B. Did you feel any of the following during the observation? Circle those which you felt.

1. Characters occasionally appeared doubled.
2. Characters occasionally appeared blurred.
3. Distance to the screen looked changed.
4. The screen looked virtually larger.
5. Feeling absorbed into the screen.
6. Body felt unsettled, like during an earthquake.

Figure 7. NHK VDT Operator Questionnaire.

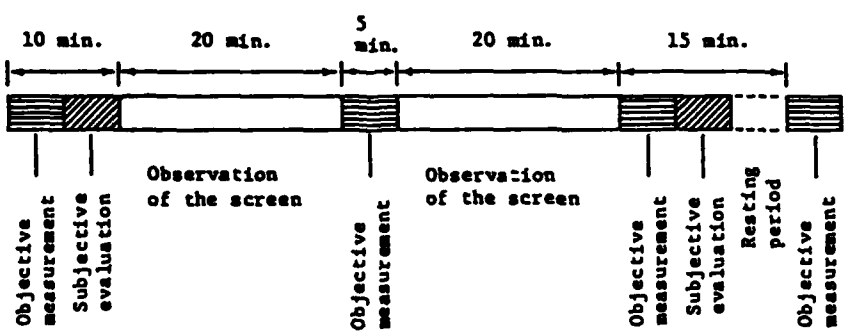


Figure 8. Experimental Plan for NHK VDT Study.

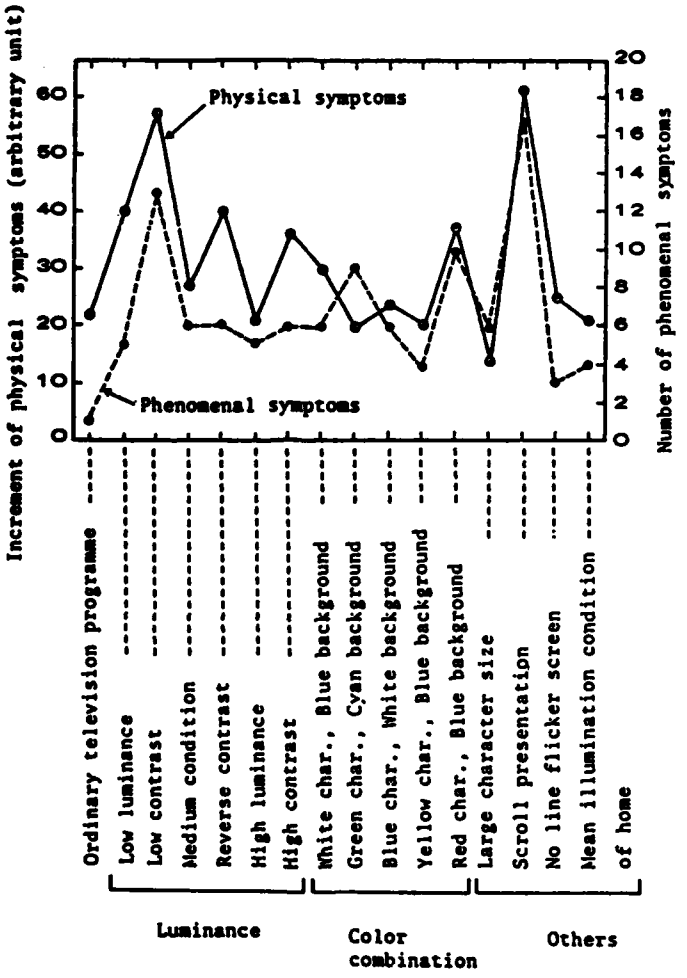


Figure 9. Physical and Subjective Evaluations of NHK Display Conditions. (N = 10)

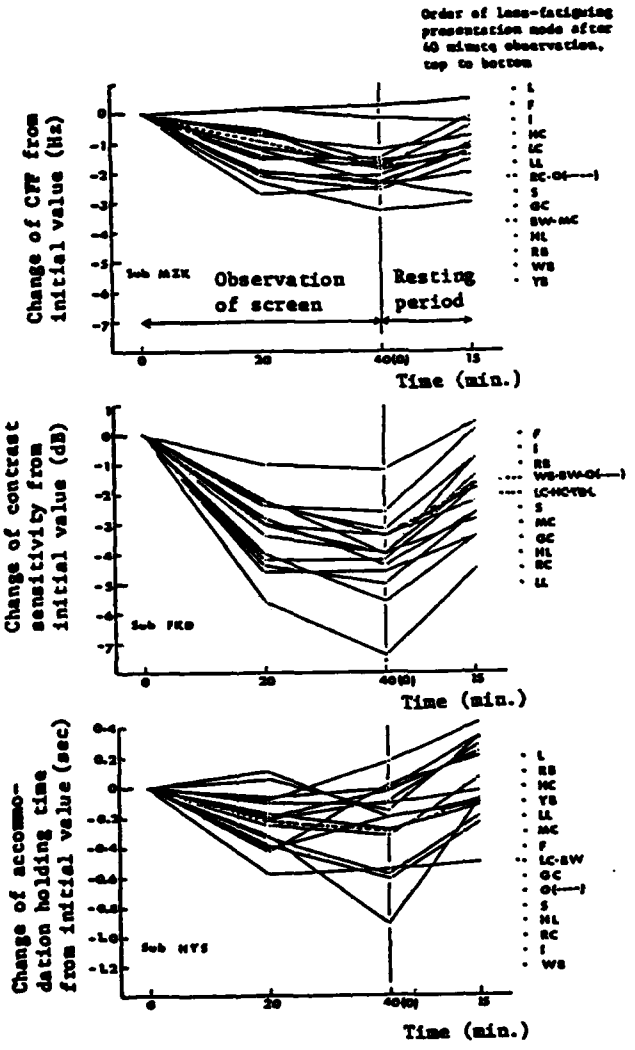


Figure 10. Objective Performance Measure as a Function of Time at the Screen.
(N = 1)

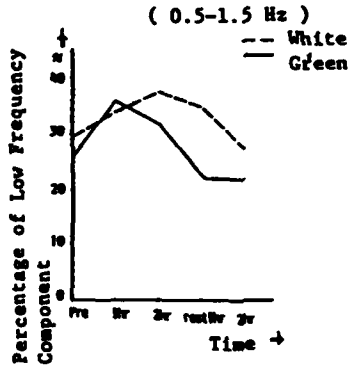


Figure 11. Visual Load (Low-Frequency Component) as a Function of Time at the Screen.

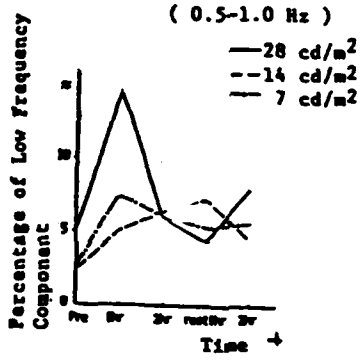


Figure 12. Visual Load (Low-Frequency Component) at Three Different Luminances.

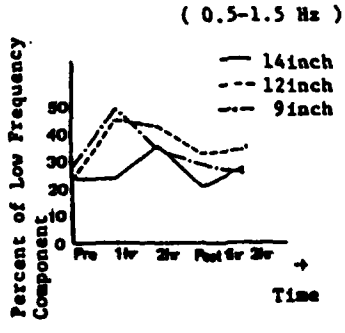


Figure 13. Visual Load (Low-Frequency Component) and Screen Size.

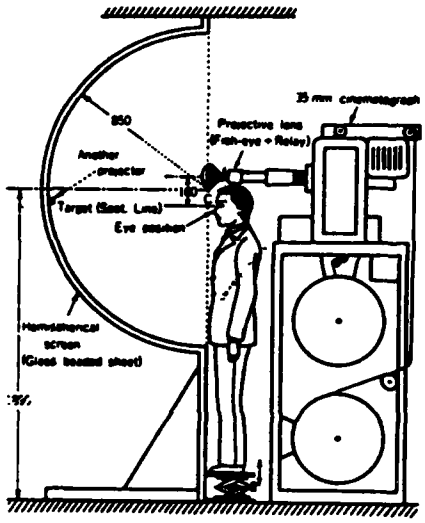


Figure 14. NHK Setup for Determining "Reality" of Wide-field Displays.

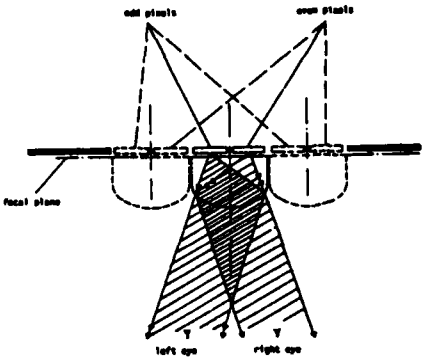
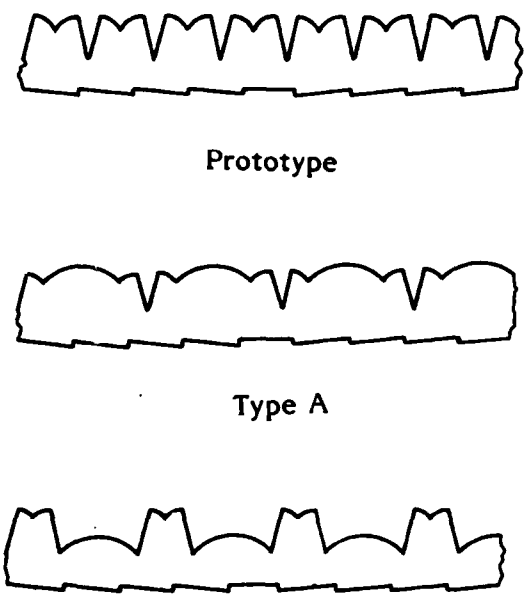
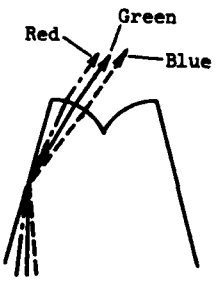


Figure 15. French Binocular-Depth Display





Color Ray Tracing

Figure 16. Matsushita Rear Screens

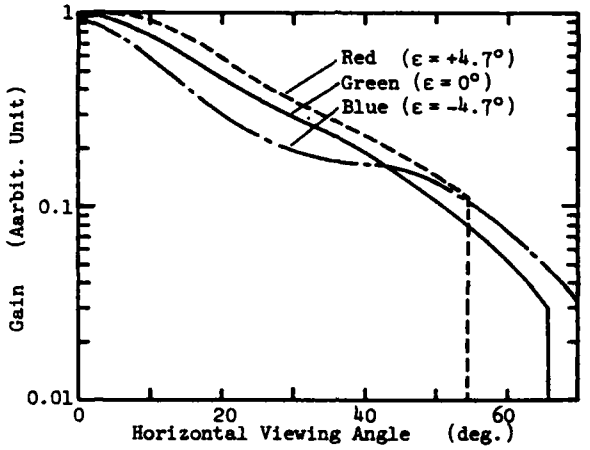


Figure 17. Brightness of Type A Rear Screen as A Function of Viewing Angle.

Figures shown in this article were taken from *Japan Display '83* published by The Institute of Television Engineers of Japan, Kikai Shinko-Kaikan, 3-5-8, Shiba, Minato-ku, Tokyo 105 Japan.

PSYCHOPHYSICS AT OSAKA DENTAL SCHOOL

Nicholas A. Bond, Jr.

INTRODUCTION

Psychophysics explores the relationships among physical stimuli and behavioral reactions. Starting from academic studies by Ernst Weber and Gustav Fechner in Germany more than a hundred years ago, a large body of knowledge has been accumulated. Statistical methods of dealing with psychophysical data have been well developed, and there are many techniques for quantifying thresholds and discrimination performance in animals and humans (Guilford, 1954). Large handbooks have been compiled on psychometric functions and response curves in the various modalities, with most of the information being devoted to vision and hearing. In the area of gustation and mouth sensitivity, a leading research center is the Dental School at Osaka University. Professor Yoshiro Kawamura and his colleagues have been investigating such matters as gustatory reaction time, interdental dimensional discrimination, and the swallowing threshold.

DISCUSSION

For their reaction time (RT) measurements, the Osaka investigators applied salt-soaked circles of paper to a marked spot on the subject's extended tongue (1.5 cm from the tip, 0.8 cm from the left edge). Different stimulus conditions used paper which had been soaked in systematically varied NaCl concentrations. Electrical arrangements for recording the exact time of application were accomplished via a low-current indicator circuit between the metal forceps holding the stimulus paper and a lead attached to the subject's hand. Subjects were told to press a response button as soon as the taste was recognized. Their responses were recorded automatically, and the mouth was rinsed with distilled water between trials. Counterbalanced stimulus presentation order, repeated presentations, and other standard experimental controls were maintained.

Subjects also estimated the intensity or magnitude of the salty taste experience by means of a direct scaling procedure. A standard NaCl concentration (0.5 M NaCl) was "set" arbitrarily as 10; if a test stimulus seems twice as strong it was given a 20, if half as strong, it would be rated a 5, and so forth. After each test stimulation, the standard 10-reference solution was applied again, and the mouth was rinsed. For some experiments, size of the stimulus disc of paper was also varied, with diameters varying frm 2.0 to 15.0 mm.

All the experimental procedures apparently yielded reliable data for reaction time, and for perceived intensity as a function of concentration and stimulus disc size. When the stimulation area was fixed and concentration was varied, the reaction time was on the order of a second or two for weak solutions; it dropped quickly to an apparent minimum at about 800 msec with the higher concentrations. Most of the curves look hyperbolic, as can be seen in Figures 1a and 1b. In fact, simple power functions fit the data quite well, with perceived intensity being linear with both concentration and stimulus area, when log-log paper is used for scaling; Figure 2 shows one example of the remarkable linearity observed.

When stimulus area was varied but a fixed concentration was applied, reaction time dropped as the stimulus series worked up from the threshold so that after an area of 50 mm was reached, additional size did not produce substantially quicker reactions. Some size data are depicted in Figure 3.

Perceived intensity itself was related to reaction time, as might be expected, and an apparently hyperbolic relationship could again be discerned from some of the graphs. Figure 4 illustrates this, and it also shows that the curves are a little "gentler" than those obtained with concentration as the variable. A fitted hyperbola would not be quite so rectangular.

To put together the essential relations among reaction time (T), perceived intensity (S), and chemical concentrations (C), the Kawamura group uses only a few simple prediction equations. An example is

$S = mC^n$, where
S = perceived intensity, C is concentration, and m and n are fitted constants.

To predict reaction time from concentration, the equation is:

$$T = T_{min} + \frac{b}{\log \frac{C}{C_0}}, \text{ where}$$

T = reaction time,
T_{min} = minimum reaction time,
C = concentration,
b = fitted constant,
C_0 = threshold concentration

When comparing their results to other studies reported from laboratories around the world, the Osaka group noted that "Osaka reaction times" were appreciably slower than the classical handbook values, and indeed were slower than previous Osaka parameters. They attribute the discrepancy to method of stimulation; if the salt stimulus is applied to the tongue as a flow of liquid solution, then RT's are shorter. Apparently, "lightly applied" disc stimulation does not recruit as many reactors as does the flow method. The power exponents (near 0.5) which the Osaka project fitted to the response curves were quite similar to those in the literature. As in other modality models, such exponents jump around appreciably when different stimulation methods are employed, and there is certainly no reason to believe that any given exponent is "the basic one" for taste RT.

The Kawamura team's recent research on interdental dimension discrimination (IDD) stemmed from some Osaka work in the late 1970s. When a normal subject has to judge which of a pair of sticks inserted in the mouth is larger, there is a tendency to judge the first stick as larger (when they are actually the same). Calling this bias tendency "directional specificity, the Osaka researchers found that such a judgment bias was strongest for a small (10 mm) mouth opening and was weak or nonexistent in a wide-mouth (45 mm) judgment. A possibility, then, was that muscle length might contribute to activity of receptors, and hence to the response bias. Parametric studies were clearly indicated.

For these trials, a subject sample of 23 Japanese adults were engaged; 12 were young with no disorders (nine males, three females, mean age 24); and 11 were older edentulous subjects (four males, seven females, mean age 63). For dentate subjects random presentation of nine acrylic test sticks was done, while the subject maintained one of four (10 mm, 20 mm, 30 and 40 mm) levels of mouth openings. The experimental series were planned so that each standard test discrimination was judged 10 times. Edentulous subjects were tested at three openings:

- 10 mm,
- height of the intercuspal position (ICP) of the dentures, and
- the overclosed position, or ICP-5 mm.

For the 10 mm condition, dentures were worn, while for the other two openings a special acrylic baseplate was fixed to the upper and lower alveolar ridges. Also, each edentulous subject was stimulated at the overclosed position with a commercial physiotherapy vibrator (110 Hz, *circa* 0.5 mm displacement), to explore the effects of vibration on the discriminatory thresholds.

Since the subjects judged the stimulus sticks to be thicker, thinner, or equal to the standard stick, curves could be plotted of the manner in which these judgments related to (real) stimulus conditions. Figure 4 displays some results for the dentate subjects, with data from the 40 mm opening at Figure 4a and 10 mm opening in Figure 4b. Difference limens or thresholds (DLs) were calculated, as was the point of subjective equality (PSE). (The PSE reflects the following operation; if a standard stimulus S_S is presented over a sequence, and a subject judges some ancillary stimulus S_A as being "equivalent" to S_S, then the mean or median of the S_A values is the PSE for that sequence and situation.) As the PSE is shown by the arrow in the Figure 4, it indeed seems that directional specificity can be observed with low degrees of mouth opening; the bias amounts to something like 0.3 mm for a 10 mm opening, and disappears with a wider mouth stimulation. The psychometric function curve also tends to be steeper around the PSE at the lower opening.

Some of the results from edentulous subjects appear in Figure 5, which displays in Figure 5a the PSE and curves for the overclosed plate condition, and summarizes in Figure 5b the vibratory trial. With vibration, directional bias essentially vanishes even when the mouth is overclosed.

The difference threshold was about half a millimeter for all conditions, and was not related systematically to degree of mouth opening. Among the incidental observations was that some edentulous subjects could not reliably perceive that they were holding a stick in their mouths at the overclosed position; if vibration was added, however, they could detect the stimulus. The Osaka researchers hypothesize that this reinstatement of performance depends partially upon increasing the stiffness of the muscle spindle poles, and also from fusimotor activation caused by the vibrator.

Since the relation of directional specificity, and degree of mouth opening is essentially shallow slope linear, as seen in Figure 6, how is this to be explained? Osaka thinking is that intrafusal viscosity of fibers is a key factor. If these fibers were to be more viscous under small openings, their relaxation time following contraction might be affected. Suppose that a stick is held or clamped at the overclosed position; release does not necessarily involve much active opening of the mouth, but relaxation time would be prolonged. This interpretation merges well with previous studies of patients with generalized muscular dystrophy (Duchene's dystrophy). For such patients, relaxation time is apt to be prolonged, and the directional specificity is greater than in normals.

According to much older studies of mouth function, the dexterity of the mouth in exerting force, masticating, and in tapping of the mandible, medium mouth openings are often the optimal ones. But since neither the difference limens nor the IDD's were best accomplished at the intermediate position, the present Osaka results indicate that the correlation of muscular sensations with motor control is far from simple.

If a thinner test stick is more easily discriminated from a standard stick than is a thicker stick, then it would be reasonable to suppose that such ability would be useful to the organism in detecting decreases of food particle size during mastication; but that might be just reasonable speculation. There are major questions associated with how the IDD is integrated with other masticatory functions. As an incidental observation, the Kawamura team had noticed previously that the IDD directional specificy was reduced when the discrimination was performed in a supine position, and furthermore that the swallowing threshold also changed. A new experiment was undertaken to explicate some of the psychophysical variables in the sitting-supine postural shift.

Twenty-four young male subjects were employed; all had at least 28 natural teeth, normal occlusion, and no disorders of masticatory muscles or temporomandibular joints. IDD test procedures were generally the same as those described previously: nine test sticks, a 10 mm standard stick, ten repeated trials per parameter estimate, and so forth.

Swallowing thresholds were determined by measuring the pulverization of peanuts to a level acceptable for swallowing. In each of five 3 g portions, a subject chewed the peanuts until ready to swallow, at which point the chewed portion was expectorated and put through a succession of mesh screens (10, 20, 40, 100, and 200 mm mesh). Two thresholds were determined for each subject. One index was taken as the ration of the volume of particles passing the 10-mesh screen to the total volume of food material expectorated. During the time of mastication, number of chewing strokes was electrically recorded. A second measure of masticatory performance was the 10-mesh total weight ratio, with the number of chewing actions limited to 20.

It turned out that when supine, the PSE was significantly lower, and the swallowing threshold increased slightly. Thus with a supine position there was some tendency to pulverize the food more before swallowing. The PSE is a statistical estimate, and somewhat of an abstraction; nevertheless, the differences in PSE, across sitting and supine, were significantly correlated with the differences (again across the two postures) in swallowing threshold and chewing strokes. The Pearson correlations, furthermore, were high enough (≈ 0.57) to support the idea that such functions as IDD specificity were exerting some real impact on masticatory decisions. Other Osaka results have implicated the temporalis muscle as a major source of sensory information; it contains a relatively large number of muscle spindles.

Much of the oral physiology work at Osaka was supported by grants from the Japanese Ministry of Education, and that support is continuing. In November 1983, Professor Kawakura was awarded the Elmer Best Memorial Award for his research; the presentation was at the American Embassy in Tokyo.

REFERENCE

Psychometric Methods, by J. P. Guilford. 2nd ed. McGraw-Hill, New York, 1954.

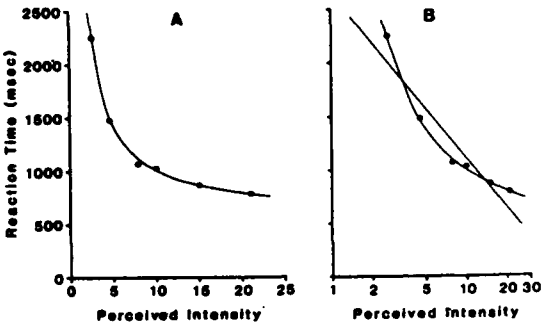


Figure 1. Reaction Time and Perceived Intensity

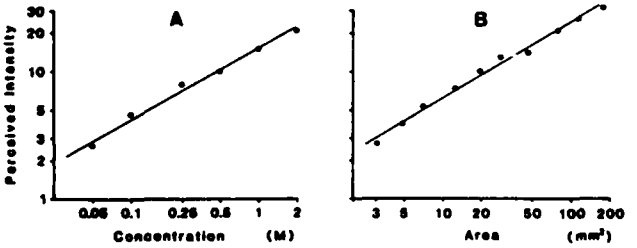


Figure 2. Log-log Plot of Perceived Intensity against Concentration and Stimulated Area

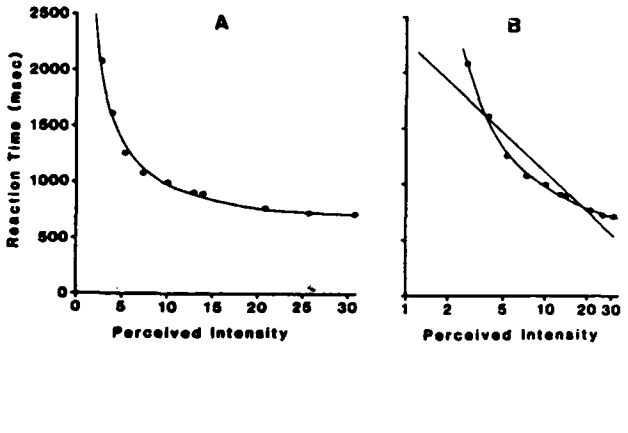


Figure 3. Reaction Time and Perceived Intensity (Fixed 1.0 M Concentration)

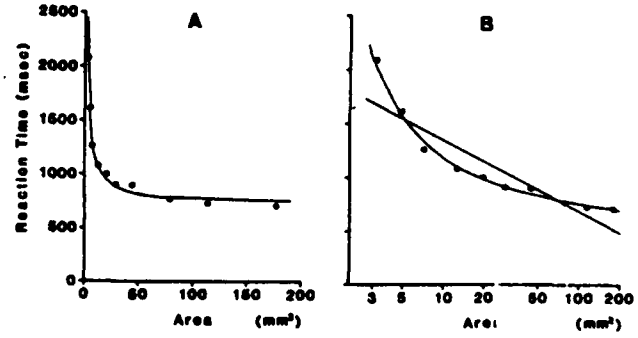


Figure 4. Reaction Time and Perceived Intensity (Fixed 78 mm² Area)

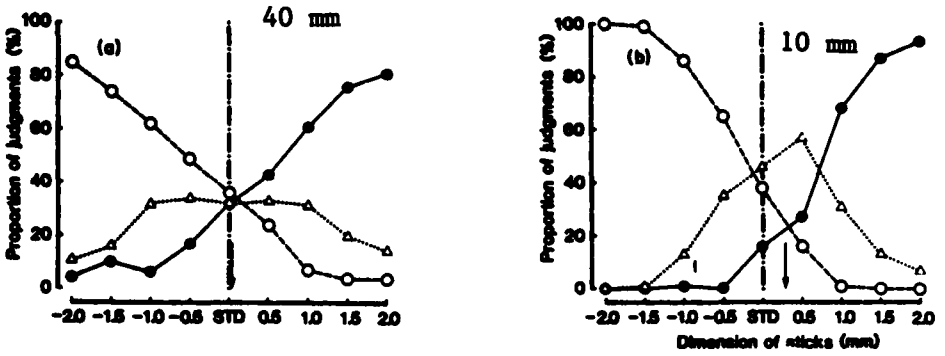


Figure 5. Three-category Psychometric Functions for 12 Dentate Subjects
Δ = "Thicker"
0 = "Thinner"
Δ = "Equal"
(The ordinate shows the proportion of judgments in each category; STD is the "standard stick" point.)

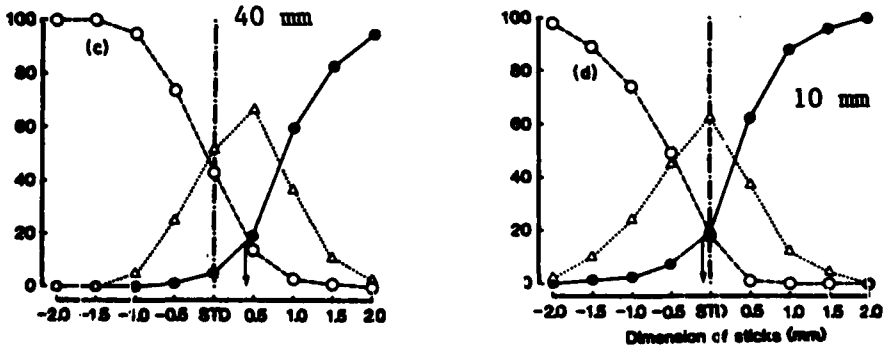


Figure 6. Three-category Psychometric Functions for 11 Edentulous subjects

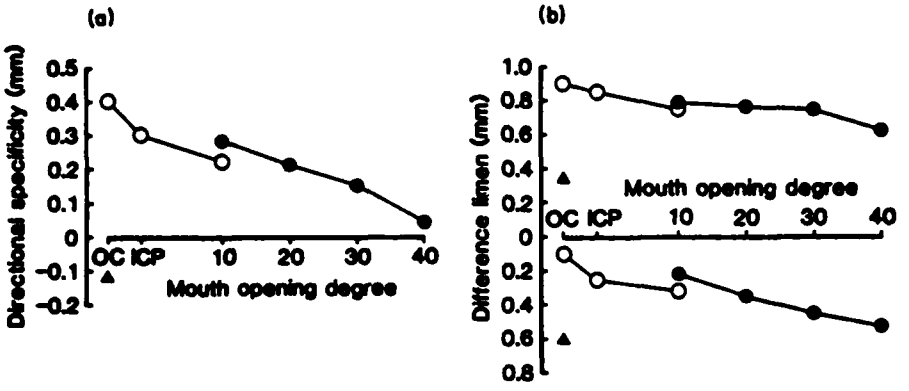


Figure 7. Magnitude of Directional Specificity and Difference Limens plotted against Degree of Mouth Opening

A PROFILE OF THE INSTITUTE OF LOW TEMPERATURE SCIENCE, HOKKAIDO UNIVERSITY, JAPAN

Sung M. Lee

INTRODUCTION

The Institute of Low Temperature Science, located in Sapporo, Japan, is one of the leading laboratories dedicated to basic research in cold environments. It was established in 1941 as an autonomous unit of Hokkaido University. The institute's objective is to conduct fundamental research on natural phenomena occurring in low temperature climates. The location of the main laboratory and its field stations on the island of Hokkaido is ideal for this purpose.

FACILITIES

The main laboratory is located adjacent to, and as part of, the Hokkaido University in Sapporo. The institute also operates a branch laboratory, the Sea Ice Research Laboratory, in Monbetsu along the Okhotsk seacoast, and three field observatories:

- avalanche study, Toikanbetsu,
- frost heaving study, Tomakomai, and
- snow melt study, Moshiri.

The main laboratory building is a modern three-story structure that contains research laboratories, administrative offices, and workshops. It also houses 32 cold rooms of various sizes which can be maintained at temperatures as low as -80° C. Some of these cold rooms are used to conduct experiments in a sustained low temperature; some are used to store ice and snow samples from remote locations including the Antarctica; one of them contains a wind tunnel.

Some of the scientific apparatus at the institute include:

- x-ray diffraction apparatus
- color data processing system
- high pressure apparatus
- ice and frozen soil core drill
- microscopic video recorder system
- automatic recorder of avalanche occurrence
- frost heave test system
- soil moisture meter using neutron diffraction
- snow depth recorder
- meteorological data logging and processing instrument with radiometers and actinometers of various types
- weather satellite receiver
- Michelson interferometery
- ultrasonic sensible heat flux measuring system
- differential thermal analyzer
- nuclear magnetic resonance spectrometer
- insect incubator
- greenhouse
- electron microscope

- freezing microscope
- liquid nitrogen preparation apparatus
- analytical ultracentrifuge
- preparative ultracentrifuge
- liquid scintillation counter
- ultracooling bath
- sea ice radar system and radar buoy (Sea Ice Research Laboratory in Monbetsu)

The weather satellite receiver is connected to a continuous recording monitor system so that the weather information can be printed out on a real time basis.

ORGANIZATION AND STAFF

The institute is under the leadership of its director, Dr. Seiiti Kinosita, who is now in the second term of office since he became director in 1980. Approximately 90 staff members make up the institute's work force, of which 49 are professional scientists (13 professors, 10 assistant professors, four lecturers, 22 research associates).

The institute is used as a laboratory for postgraduate students in geophysics, biology, and biochemistry. Currently, there are 26 students pursuing Masters degrees and 26 students, including two from universities other than Hokkaido, pursuing Ph.D. degrees, under the supervision of the institute staff.

The staff is organized as shown in Table I.

RESEARCH ACTIVITIES

The research program at the institute is very comprehensive and wide-ranging. The depth and breadth of the research carried out makes this institute truly unique. The following describes the research topics for each section:

- Physics

  Growth and morphology of ice crystals from vapor
  Boundary structure of polycrystalline snow crystals
  Formation mechanism of polycrystalline snow crystals

- Applied Physics

  Designing and improving of ice core drill
  Microwave sensing of snow pack and its characteristics
  Water percolation in snow pack and permafrost
  O^{18} distribution in snow pack and permafrost
  Plastic deformation of snow pack
  Stress distribution in snow pack on slopes
  X-ray topography of snow crystal

- Meteorology

  Physical properties of snow, ice and sea ice including acoustics, permeability, electrical and mechanical properties, and their meteorological and climatic implications in snow drift, fluidized snow, polar ice sheets, etc.

- Oceanography

Variations of sea conditions preceding the sea-ice season in the Okhotsk Sea
Haline convection under a growing sea ice
Behaviors of brine in sea ice
Strength and friction coefficient of sea ice
Deflection of a floating ice sheet subjected to a moving load
Researches in sea ice using satellite data

- Snow Damage

Mechanism of avalanche release (stresses within a snow cover on slopes)
Mechanical behavior and structure of snow under tensile and shear stress with relation to initiation mechanism of avalanches
Characteristics of the snow cover in Hokkaido

- Frost Heaving

Frost heaving force
Coupled heat and moisture transfer during soil freezing
Behaviors of unfrozen water in frozen soil
Mechanical and thermal properties of frozen soil
Adfreezing
Frost heave character of powder materials
Permafrost expedition

- Snowmelt

Heat balance at the surface of a snow cover, its areal and seasonal characteristics
Snowmelt runoff and variation in stream temperature
Influence of amount of snow upon delay in snowmelt runoff
Areal distributions of snow accumulation and ablation
Absorption of solar radiation within deposited snow
Continuous observation of snow melting at the bottom of snow cover in connection with base flow of a stream in winter
Practically convenient and simple methods for preestimation of melting rate of snow

- Solid Precipitation Physics

Solid precipitation-forming processes in cloud
Formation processes of snowflakes and growing mechanism of graupels
Motion and trajectories of snow crystals, snowflakes, and graupels in clouds and air
Influences of topography on the intensity and total amount of snowfall

- Frost Injury in Plants

Chemical and physical properties of plant plasmamembrane with respect to cold acclimation and freezing injury
Freezing avoidance and freezing tolerance in plants
Ultrastructural changes of hardy cells related to freezing tolerance

Cryopreservation of plant apical meristems
Strategies of cold adaptation of plants against cold climate
Adaptation to cold climate of ferns in Hokkaido with reference to the alteration of generations

Zoology

Physiological and ecological studies of overwintering insects
Cold hardiness and diapause in *Lepidoptera* and *Drosophilae*
Cold hardiness and distribution of overwintering insects

- Physiology

Adaptation of cell structure and function to low temperature environment in higher plants
Contribution of water to stabilization of biological membranes
Protein hydration and its relation with protein stability in frozen state
Structural and functional changes in microbial membranes

- Biochemistry

Metabolic regulation of overwintering insects
Molecular mechanism of lipid transport in insects
Endocrinological and biochemical studies on an *Amphibia* exposed to low temperature

- Sea Ice Research Laboratory

Ocean dynamics in coastal regions
Drift and deformation of pack ice using a sea-ice radar
Aerial survey of roughness of sea ice
Crystallographic orientation of sea ice
Optical properties of sea ice

RESEARCH PUBLICATIONS

The results of the research are published in the *Journal of Low Temperature Science* and also in *Contributions from the Institute of Low Temperature Science* (Series *A* - Physics; Series *B* - Biology). The articles in the *Contributions* are printed in Japanese but with English summaries at the end of each article. Some of these articles have also appeared in translated summary versions.

SOME OBSERVATIONS

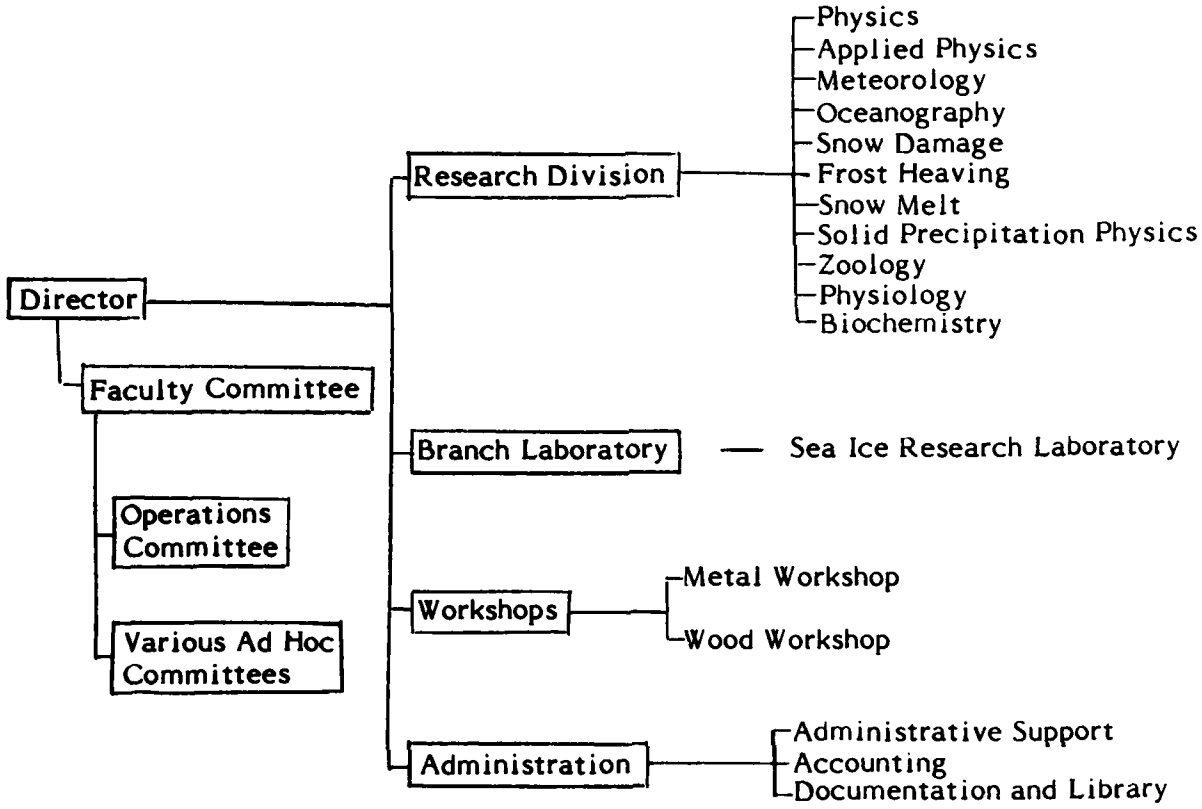
A visitor's first impression of the institute is likely to be the outwardly calm atmosphere of the laboratory. It does not take long for any working scientist to realize that much work is going on in the laboratory. Most of the laboratory counter space is crowded with equipment which is being used and the blackboard shows traces of discussions among the staff. The research output as evidenced by the publications and the number of postgraduate students is a strong testimony to the active nature of the institute.

Those scientists in the United States who are engaged in snow and ice research will find the Institute of Low Temperature Science a rich resource for their work.

For further information, contact:

Dr. Seiiti Kinosita, Director
Institute of Low Temperature Science
Hokkaido University
Sapporo, Japan 060

TABLE I


Director
Faculty Committee
Operations Committee
Various Ad Hoc Committees
Research Division
Physics
Applied Physics
Meteorology
Oceanography
Snow Damage
Frost Heaving
Snow Melt
Solid Precipitation Physics
Zoology
Physiology
Biochemistry
Branch Laboratory
Sea Ice Research Laboratory
Workshops
Metal Workshop
Wood Workshop
Administration
Administrative Support
Accounting
Documentation and Library

INTERNATIONAL MEETING ON CHEMICAL SENSORS

Sachio Yamamoto

The International Meeting on Chemical Sensors was held 19-22 September 1983 in Fukuoka, Japan, under the sponsorship of the Electrochemical Society of Japan and the Researchers Association for Chemical Sensor Development. It was fitting that this meeting was held in Fukuoka, Japan, since this country is most active in the area of chemical sensor development and the laboratory of Professor Tetsuro Seiyama, the chairman of the meeting, of Kyushu University, is one of the leading laboratories in this field. The meeting was extremely well organized. The attendance of more than 400 far exceeded the expectations of the organizers. About 85 of the attendees were from overseas and most of them were from Europe (particularly West Germany and France). The scientific program was divided into seven sections (the number of papers are in parenthesis):

semiconductor gas sensors (40)
solid electrolyte sensors (25)
humidity sensors (14)
FET chemical sensors (10)
ion-selective electrode sensors (11)
biosensors (21)
new methods and systems (11)

- Semiconductor Gas Sensors

Semiconductor gas sensors typically consist of metal oxides such as SnO_2, ZnO_2, TiO_2 and Fe_2O_3 (n-type) and CuO, NiO, and CoO (p-type). Among them only SnO_2 and Fe_2O_3 are in commercial use and by far the greatest number of papers dealt with SnO_2 sensors. A majority of the papers in this section were concerned with improvements in sensitivity and/or selectivity by various means.

Several papers were concerned with the use of additives. Among them N. Yamazoe, Y. Kurokawa, and T. Seiyama of Kyushu University found that the sensitivity of SnO_2 to hydrogen is increased markedly by the addition of small amounts (0.5 wt.%) of Ag and that the Ag-SnO_2 system is nearly six times more sensitive than Pd-SnO_2; Y. Matsukawa, N. Murakami, and K. Ihokura of Figaro Engineering Company, Osaka, reported that the sensitivity of SnO_2 sensors to hydrogen varied with the amount of Pd and SiO_2 binder added; and Y. Okayama and co-workers from Nohmi Bosai Kogyo Company, Ltd., Tokyo, and the Science University of Tokyo, found that sensitivity and response time of SnO_2 ceramics for CO gas was maximized by addition of 4 mole% of Pt and Sb and that the sensor was minimally affected by changes in environmental temperature or humidity.

Improvement of performance by various treatment and preparation methods were reported by K. Murakami, *et al.* of the Figaro Engineering Company of Osaka, who found that sensitivity to C_2H_5OH, CO, H_2, CH_4 and C_4H_{10} increased with an increase in final sintering temperature; K. Fukui and K. Komatsu of New Cosmos Electric Company, Ltd., Osaka, who improved selectivity for H gas by coating the surface of sintered SnO_2 with a 0.2 mm layer of SiO_2; N. Komori, S. Sakai, and K. Komatsu, also of the New Cosmos Electric Company, who improved selectivity for methane in the presence of H_2, CO and ethanol by sintering a thin layer of SnO_2 on an alumina substrate; and R. Lalauze, N. D.

Bui, and C. Pijolat, of the Ecole Nationale Supérieure des Mines de Saint-Etienne, France, who reported that selectivity on SnO_2 sensors for gases such as ethylene, butane, pentane, and toluene could be increased by treatment with 1000 ppm SO_2-air mixture at 500°C.

Among the other oxides there were seven papers on ZnO, two on TiO_2 and one on Fe_2O_3. Among other materials discussed, M. Kuwabara and H. Inoue of the Kyushu Institute of Technology, Tobata, Kitakyushu, reported on the effect of gases such as air, O_2, N_2, CO, CO_2, and CH_4 on the electrical conduction in porous semiconducting barium titanate ceramics; C. Nylander, M. Armgarth, and I. Lundstrom of Linkoeping Institute of Technology, Sweden, who demonstrated that a conducting polymer such as polypyrrole can be used to detect ammonia gas in the concentration range from a few ppm to several percent; and J. R. Kruger, *et al.*, who studied the use of heated metal catalysts such as beaded alumina impregnated with Pt, Pd, or Ir as methane sensors.

In a plenary lecture, G. Heiland and D. Kohl of Physikaliches Institut der Rheinisch-Westfallischen Technischen Hochschule, Aachen, West Germany, reported the reactions on the surfaces of single crystals of SnO_2 and ZnO after exposure to H, H_2, H_2O, CH_3OH, and C_2H_5OH. They found that surface reactions and conductivity changes are different on prism and oxygen faces. In another plenary lecture, P. K. Clifford of Carnegie-Mellon University presented a model to explain the gas response of homogeneous semiconductor sensors. It is based on a three-step process:

- physisorption of oxygen on disordered surfaces,
- reactive desorption of physically adsorbed oxygen by the action of combustible gases, and
- barrier layer limited ionosorption of oxygen.

- Solid Electrolyte Sensors

Solid electrolyte sensors are concentration cells with a solid electrolyte such as stabilized zirconia. Plenary lectures in this section were presented by M. Kleitz, E. Siebert, and J. Fouletier of the Laboratoire d'Energétique Electrochimique, St. Martin d'Heres, France, who reviewed recent developments in potentiometric solid electrolyte oxygen sensors and K. S. Goto of the Tokyo Institute of Technology, who reviewed chemical sensors with solid electrolytes at high temperatures.

Nearly half of the papers in this section dealt with oxygen sensors. Among them, K. Ando and Y. Oishi of Kyushu University, measured the oxygen self-diffusion coefficient of CaO-stabilized zirconia by gas-solid isotope exchange using ^{18}O as a tracer; T. Suzuki, *et al.* of Tokyo University of Agriculture and Technology, reported on MoO_3-doped Bi_2O_3; and J. Mizusaki, *et al.* of Tokyo University on zirconia. Hydrogen sensors were discussed by H. Iwahara and H. Uchida of Tottori University who used sintered $SrCe_{0.95}Yb_{0.05}O_3$ - as the electrolyte; N. Miura, *et al.* of Kyushu University who proposed the use of proton conductors such as Nafion membrane and zirconium phosphate for detecting small amounts of H_2 or CO in air at room temperature; and J. S. Lundsgaard, *et al.* of Odense University, Denmark, who studied hydrogen uranyl phosphate as a possible sensor. There were four papers on sulfur oxide sensors. Among them W. L. Worrell and Q. G. Liu of the University of Pennsylvania discussed sodium sulfate electrolyte as SO_2 /SO_3 sensors and N. Imanaka, G. Adachi, and J. Shiokawa reported on sodium sulfate doped with $NaVO_3$ and/or $Ln_2(SO_4)_3$ (Ln = rare earths). In an interesting application of a solid electrolyte sensor, T. Matsui, M. Murata, and K. Naito of Nagoya University used a CaO-stabilized zirconia electrolyte to measure chemical diffusion coefficients in NbO_2 using the following galvanic cell:

$$Pt(1) \mid ZrO_2(15\ mole\%\ CaO) \mid NbO_2 \mid Pt(2)$$

- Humidity Sensors

Humidity sensors are based on the fact that the electrical conductivity of a metal oxide is affected by surrounding water vapor. Commercial sensors developed in Japan use sensor elements consisting of porous ceramics such as $MgCr_2O_4$ or sintered metal oxide such as Al_2O_3. Among ceramic elements described were $ZnCr_2O_4$-$LiZnVO_4$ by S. Uno, *et al.* of the Toshiba Research and Development Center, Kawasaki, and ZrO_2-MgO by T. Nitta, F. Fukushima, and Y. Matsuo of Matsushita Electric Industrial Company, Osaka. Semiconductor-type sensors were reported by H. Arai, *et al.* of Kyushu University who studied perovskite-type oxides such as $CaTiO_3$, $CaSnO_3$, $SrTiO_3$, and $SrSnO_3$ and G. J. Rogers, *et al.* of GEC Research Laboratories, Wembley, U.K., who studied hygroscopic dielectrics such as cellulose acetate butyrate and porous aluminum oxide. Among other materials reported were cross-linked polyelectrolyte (sodium styrenesulfonate polymerized and cross-linked with N,N'-methylenebisacrylamide) by M. Miyoshi, *et al.* of Sharp Corporation, Nara, and composite films of silicone polymer and metal oxides by F. Uchikawa, *et al.* of Mitsubishi Electric Corporation, Kamakura.

- FET Chemical Sensors

In a plenary lecture, M. Croset, and G. Velasco of Laboratoire Central de Recherches Thomson-CSF, Orsay, France, described micro-ionic gas sensors in which ionic conductor devices were fabricated using microelectronics technologies. They described a thin-film zirconia-based oxygen sensor and its use in monitoring the air/fuel ratio of an internal combustion engine. In the second plenary lecture in this section, A. Spetz, *et al.* of Linkoeping Institute of Technology, Sweden, described Pd-gate metal oxide semiconductor (MOS) devices, which were modified by coating the gate with a thin film of metals such as Pt, Ir, and La to improve sensitivity for ammonia gas detection. Other MOSFETs described were SnO_2-, Pd-, and Pt-gate devices for CO detection by K. Dobos, D. Krey, and G. Zimmer of Universitat Dortmund, West Germany and a Pd-gate device for hydrogen sulfide detection by J. P. Couput, B. Cornut, and C. Chambu, Société Nationale Elf-Acquitane, Centre Recherche de Lacq, France. B. Danielson, F. Winquist, and K. Mosbach of the University of Lund, Sweden, discussed the use of hydrogen- and ammonia-sensitive Pd-gate MOS devises as detectors for biochemical reactions which produce or consume these gases. Ion-sensitive FET (ISFET) devices were described by S. Shoji, M. Esashi, and T. Tasuo, Tohoku University, Sendai, who described the fabrication and characteristics of a 10 μm tip size micro ISFET for use in biomedical studies; W. H. Ko, *et al.* of Case Western Reserve University, who described a multiple ISFET device for measuring pH in the range from 4 to 10; and by Y. Hanazato and S. Shiono of Mitsubishi Electric Corporation, Amagasaki, Hyogo, who described a bioelectrode consisting of two pH-ISFETs and a Pt-wire pseudoreference electrode.

- Ion Selective Electrode (ISE) Sensors

Among papers dealing with membranes were those by D. Ravaine, G. Perrera, and Z. Hanane of the Laboratoire d'Energetique Electrochimique, St. Martin d'Heres, France, who measured the ionic conductivity and solubility of various flouride glass compositions; Y. Inokuma, *et al.* of Sumitomo Metal Industries, Amagasaki, and the Government Industrial Research Institute, Osaka, who developed an ISE with a cation exchange membrane for measuring H^+ and HF in the 0.005 to 1 M range in pickling baths or chromate treatment baths; and T. Maruzumi, H. Miyagi, and Y. Takata of Hitachi Central Research Laboratory, Kokubunji, who made an ac impedance study of chloride ion

sensitive polymeric membranes composed of quaternary ammonium salt as the Cl^- ion exchanger, polyvinyl chloride as the membrane matrix, and an aliphatic or phenylalkyl alcohol as the plasticizer. K. Kanno, T. Gatayama, and M. Koyama of Toshiba Research and Development Center, Kawasaki, showed that electrode response of both glass and PVC membrane ISE can be accelerated by a charge pulse technique; the response time of a sodium ISE in 10^{-4}M NaCl solution was reduced from ten seconds to one. In papers by H. Gunasingham, National University of Singapore, and B. Fleet, University of Toronto, and N. Ishibashi, A. Jyo, and T. Imato of Kyushu University, the use of ISE's as HPLC detectors was described.

- Biosensors

There were three plenary lectures presented in this section. D. W. Lubbers and N. Opitz of the Max Planck Institut für Systemphysiologie, West Germany, reported on the development of membrane-protected, optically insulated fluorescence (which they call the "optode" principle) sensors for analysis of O_2, pH, and CO_2 in blood. The use of an oscillating quartz, 9 MHz piezoelectric crystal as a detector for air pollutants such as CO, organophosphorous compounds. NH_3, SO_2, H_2S, and aromatic hydrocarbons was described by G. G. Guilbault of the University of New Orleans. An excellent lecture was presented by M. Aizawa of Tsukuba University, who reviewed the development of biosensors in which biosubstances capable of molecular recognition are coupled to an electronic devise for signal transduction. He also discussed the use of chemical amplification to enhance the sensitivity of these sensors.

One-third of the papers in this section dealt with enzyme electrodes as sensors. Among them were sensors for glucose to be used in an artificial pancreas by S. Ikeda and K. Ito, Nagoya Institute of Technology; blood urea nitrogen by D. Tokinaga, *et al.*, Hitachi Central Research Laboratory, Kokubunji; L-threonine in biological fluids and foods by T. Iida, *et al.*, Saitama University; acid phosphatase by F. Mizutani, *et al.*, Research Institute for Polymers and Textiles, Tsukuba; and α-amylase activity in serum by K. Yoda and T. Tsuchida, Toyobo Company, Otsu. Three papers described sensors for *in vivo* use: a transcutaneous CO_2 electrode by Hagihara, *et al.* of Osaka University Medical School and Sumitomo Electric Industries, Ltd.; an oxygen-hydrogen electrode for cardiac catheterization also by Hagihara, *et al.*, and Al_2O_3-gate pH sensitive FET's for intravascular pH measurements. A bioaffinity sensor for biotin with a binding protein, avidin, was described by Y. Ikariyama, M. Furuki, and M. Aizawa of Tsukuba University.

A few papers dealt with new methods for the determination of biological materials. Among them was the determination of aerobic microbial concentration in activated sludge by measurement of respiration rates by S. Asakura and S. Yoshida of Yokohama National University.

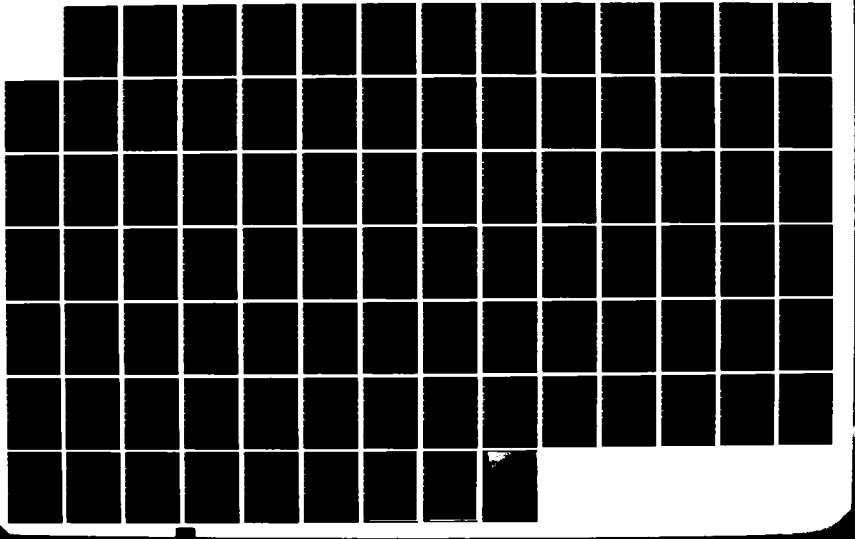
- New Methods and Systems

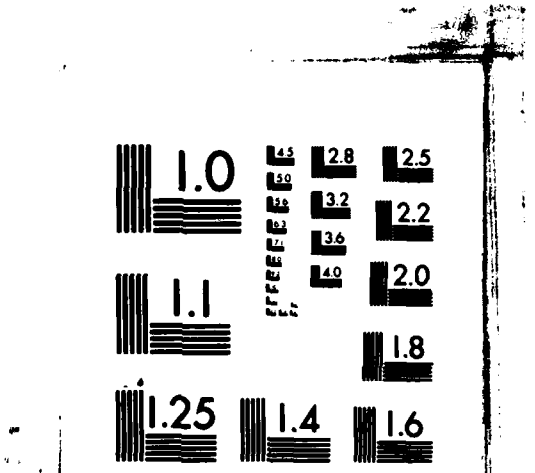
Among the systems described in this section were a halogen sensor using surface positive ionization by M. Hori and Y. Kobayashi of Yokohama National University; an immersible, microprocessor-based system for in-water measurement of dissolved oxygen, conductivity, pH, and temperature by I. Sekarka and J. F. Lechner of the National Water Research Institute, Ontario, Canada; and a corrosion monitoring sensor for marine steel structures by B. Ito, M. Yamamoto, and T. Murata of Nippon Steel Corporation, Kawasaki.

The proceedings of this meeting has been published by the:

AD-A140 826 ONR (OFFICE OF NAVAL RESEARCH) FAR EAST SCIENTIFIC BULLETIN VOLUME 9 NUMB..(U) OFFICE OF NAVAL RESEARCH LIAISON OFFICE FAR EAST APO SAN FRAN.. 2/2

UNCLASSIFIED S YAMAMOTO ET AL. MAR 84 F/G 5/1 NL





Elsevier Science Publishing Company, Inc.
52 Vanderbilt Avenue
New York, NY 10017

CHEMICAL SENSOR DEVELOPMENT IN JAPAN

As stated at the beginning of this article, chemical sensor research and development in Japan is probably the most active in the world. This results from three factors: first, Japanese homes have gas water heaters located usually in the kitchen. The very high density of these homes, which are usually of wood construction, poses a serious fire hazard. Hence, there exists in this fire-safety conscious nation a very large consumer market for sensors for combustible gases. Second, sensors are being used increasingly in automobile engines. Thus, a substantial market for sensors exists in the Japanese automobile industry which in 1982 produced 10.7 million vehicles, almost one-third of the world production. Finally, sensors are often made from new semiconductor materials and ceramics and the development of new materials is being strongly encouraged by the Japanese government. As a result, sensor development is also being promoted.

During the first half of 1983, the Government Industrial Research Institute (GIRI), Osaka, as part of the Agency of Industrial Science and Technology (AIST) of the Ministry of International Trade and Industry (MITI) conducted a study to assess the status and direction of chemical sensor research and development. Scientists of the Osaka laboratory systematically surveyed the technical literature and patents as well as scientists and engineers in academia and industry. The latter was accomplished by means of a questionnaire. A response of 48%, as opposed to 30% normally received from questionnaires, has been interpreted as evidence of great interest in chemical sensors within the Japanese technical community. The types of sensors whose development and use is expected to grow in the opinion of the respondents are shown in Figures 1 and 2. A majority of the respondents would like to see a national research program involving university, industrial, and government laboratories set up and coordinated by a national research organization. On the basis of this survey, a research program on chemical sensors will be initiated in JFY 1984 as part of a special AIST research program. The program will probably grow into a cooperative program involving industrial, government, and university laboratories.

A modest effort is underway currently at GIRI Osaka. Research is being conducted on glassy materials containing phosphorus for use as humidity sensors at high temperatures and on spherical metal oxide (mixed oxides of Co and Mn) powders with Ag additive as sensors for reducing gases.

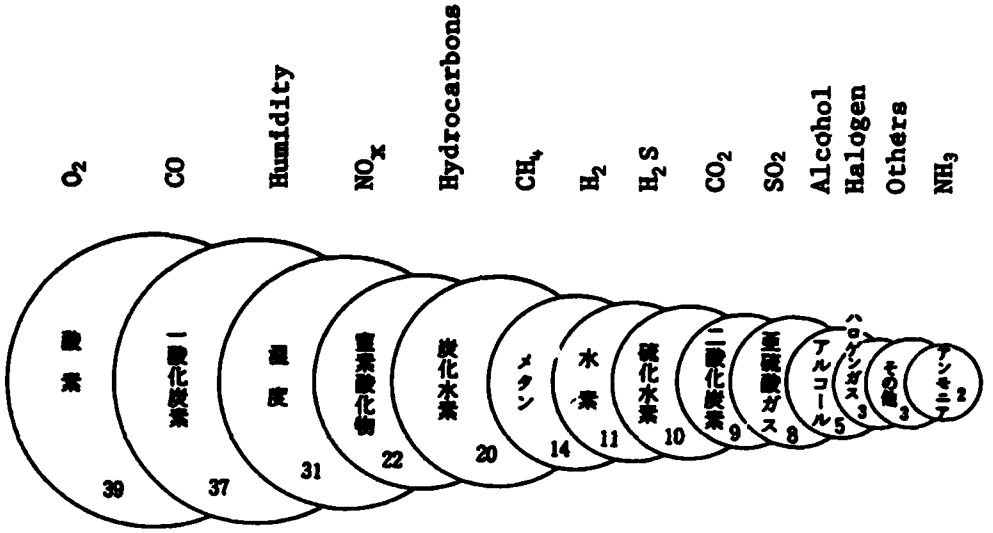


Figure 1. Gas sensors whose development and use are expected to grow in the future (the number respondents are shown).

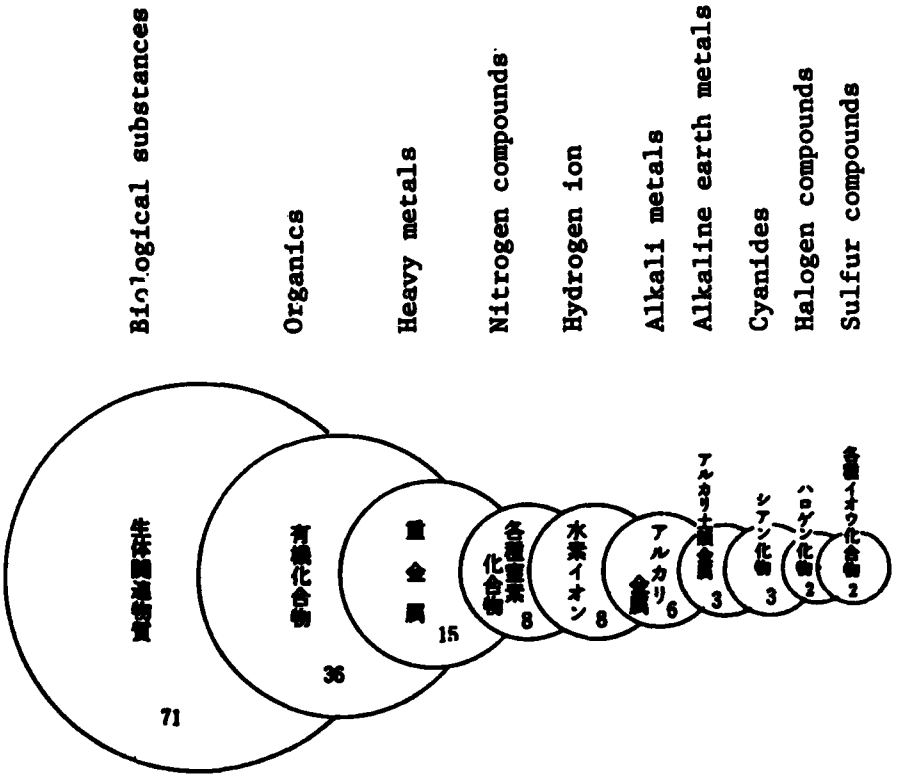


Figure 2. Ion and biosensors whose development and use are expected to expand in the future (the number of respondents are shown).

A REVIEW ON URANIUM RECOVERY PROCESSES AND THE INTERNATIONAL MEETING ON THE RECOVERY OF URANIUM FROM SEAWATER

Frederick R. Best and Sachio Yamamoto

RECOVERY OF URANIUM FROM SEAWATER

- Uranium in Seawater

Uranium exists in seawater, in the uranyl form, at a concentation of 3.3 ppb. This represents a world resource of 4000 million tons of uranium (compared to 5 million tons in ores), a potentially enormous supply if an economically and environmentally acceptable method of recovery could be developed. Recognizing this, Japan, West Germany, Sweden, South Korea, and Taiwan have vigorous programs to develop a uranium recovery process. England, Canada, France, India, and Italy have, or have had, uranium from seawater projects. The first U.S. reference to uranium from seawater occurred during the Manhattan Project when seawater was identified as a potential source of uranium. The next time that seawater was considered as a potential uranium resource was in 1964 when N. Keen of the United Kingdom published an article in *Nature* describing a recovery process based on adsorption of uranium by hydrous titanium oxide particles. He projected a cost of $24 per pound uranium. Since that time various national programs have worked to develop a satisfactory recovery process. The following paragraphs review the problems inherent in recovering uranium from seawater, describe some of the systems which have been proposed for uranium recovery, and list some of the estimated uranium recovery costs.

- Recovery Process

A conventional nuclear reactor producing 1000 Mw(e) requires 150 metric tons of yellowcake (U_3O_8) per year. A uranium from seawater recovery system recovering 100% of the uranium present in seawater must process approximately 1200 metric tons of seawater per second in order to meet this demand. Further, uranium exists as a trace element in seawater at a concentration thousands of times lower than other potentially interfering ions. The challenge is to develop a recovery process which will be highly selective for the uranyl species, will require only minute expenditures of energy or chemicals per unit of seawater, and yet will be inexpensive and environmentally benign. Almost uniformly, researchers have agreed that some type of sorption process has the best potential for meeting these requirements, and have settled on either hydrous titanium oxide (HTO) or a polyacrylonitrile functionalized with imidoxime or amidoxime groups (PAO) as the most promising sorbers. These materials have demonstrated uranium capacities on the order of 1000's of ppm in natural seawater testing programs in Japan, Germany, and the United States but either their mechanical strength or chemical stability are questionable. Moreover, the details of the process by which the uranium is sorbed are still unclear and much work is being done to develop better materials. Nevertheless, process flow streams have been designed based on these materials as described below.

All uranium recovery processes must involve a sorber contacting large volumes of seawater. Because of the enormous masses involved, very little energy can be expended during this contacting process and various schemes involving high-flow low-head pumps or natural ocean currents, waves, and tides have been investigated as pumping agents. A

natural trade off exists between compact systems using actively driven pumps and the necessarily large structures based on passive ocean interceptor schemes. The physical form of the sorber is a controlling feature of the overall recovery process. The size and shape of the sorber material sets fundamental limits on the maximum mass transfer and minimum momentum transfer. The former controls the uranium uptake and the latter the energy required to move the seawater. Large spherical particles minimize pumping power requirements but also minimize uranium uptake. Small high surface area particles maximize mass transfer but also result in large pumping power requirements. Recent work has investigated the potential of filaments, fibers, and other high specific surface media for uranium recovery.

The predominant designs may be classified as either fixed or moving bed systems and most of these rely on actively driven pumps to move the seawater. The fixed bed schemes include classical fixed particle beds as well as low bulk density fibrous mats and rolls of spun-bonded cloth. The moving beds include fluidized beds, "falling" particle beds, and dispersed-netting "seaweed" systems. None of these has yet demonstrated a clear superiority over the other systems.

Co-product recovery of other important materials with the uranium has recently received attention not only because of the potential impact on the uranium cost but also because of national defense aspects of the co-products. Cobalt, chromium, molybdenum, and vanadium have all been detected in significant quantities in the PAO-type sorbers.

- Comments

The most recent round of projected uranium recovery costs for all systems ranged from $194 per kg to $748 per kg. These may be compared with the present market price of $62 per kg. However, countries with low indigenous uranium resources and high projected energy requirements see a strong need to develop this technology.

The areas which must be investigated in the future include:

- the development of high capacity, rapid kinetic and stable sorbers, and their demonstration in at-sea recovery systems,
- the development of low pressure drop high mass transfer contactors (including dispersed systems), and their testing at sea, and finally,
- work on the environmental and legal aspects of mining the ocean itself for minerals.

The oceans of the world are a tremendous resource in terms of both energy and materials. Uranium from seawater research programs are moving technology closer to tapping this supply.

INTERNATIONAL MEETING ON THE RECOVERY OF URANIUM FROM SEAWATER

On 17-19 October 1983 the International Meeting on the Recovery of Uranium from Seawater was held in Tokyo, Japan. The meeting was jointly sponsored by the Atomic Energy Society of Japan and the International Atomic Energy Agency. There were 100 attendees of whom 20 were from overseas (four from the U.S.) and 39 papers were presented.

- Review Papers

Interest in the recovery of uranium from seawater has waned in most countries in recent years because the growth rate of nuclear power generation has decreased. An exception is Japan which must import almost all of its energy resources. The history of research and development of uranium extraction from seawater in Japan was reviewed by N. Ogata of the Tobacco and Salt Public Corporation, Yokohama. In 1975 under a commission from the Ministry of International Trade and Industry, the Metal Mining Agency of Japan (MMAJ), a joint government-industry organization, initiated a research program in this area. Funding in the first year was 150.0 million yen ($0.6 million) and in the current fiscal year (JFY 1983) 550 million yen ($2.3 million). A report on the progress of the MMAJ project was presented by Professor M. Kanno of Tokyo University and chairman of the MMAJ steering committee as well as of this meeting. In 1981, construction of a 2.5 billion yen ($10.6 million) demonstration plant with an annual capacity of 10 kg was started in Niocho, Shikoku. A schematic diagram of the plant is shown in Figure 1. M. J. Driscoll of the Massachusetts Institute of Technology reviewed recent work at M.I.T. In contrast to the Japanese project, which uses hydrous titanium oxide as the adsorber, the M.I.T. system uses an ion exchange resin, acrylic amidoxime in fiber form.

- Adsorbents

The adsorbents used for the removal of uranium from seawater are usually either hydrous titanium oxide (HTO) or chelating resins containing amidoxime groups. Ogata in his aforementioned review of uranium extraction R&D in Japan summarized the characteristics of the two adsorbents as shown in Table I.

Among discussions of HTO were those by C. H. Liang and T. Chen Huang of the Institute of Nuclear Energy Research, Taiwan, who found in recycle tests that HTO microspheres maintained their mechanical strengths and physical properties; T. J. Wen and T. Chen Huang, also from the Taiwan institute, who found that the adsorption capacity of Ti-Fe hydrous oxide microspheres at 72 μg U/g ads was similar to that of HTO microspheres; and M. Yamawaki, *et al.* of Tokyo University, who reported on a study of the adsorption rates of both HTO and amidoxime resin.

A majority of the papers on adsorbents dealt with amidoxime-type chelating resins. K. Schwochau and his coworkers from the Nuclear Research Center, Juelich, West Germany, presented a comprehensive discussion of the performance of polyacrylamidoxime resins. Preparation of fibrous adsorbents containing amidoxime groups was discussed by K. Sakane, *et al.* of the Government Industrial Research Institute, Shikoku, Tokyo University, and Mitsubishi Chemical Industries, Ltd., Yokohama, who prepared the material from commercial acrylic fibers by reacting with hydroxylamine in methanol and by J. Okamoto, *et al.* of the Japan Atomic Energy Research Institute, Takasaki, who used radiation-induced graft polymerization of acrylonitrile onto the fiber of tetrafluoroethylene-ethylene copolymer followed by a chemical conversion of the cyano group into amidoxime. Two other types of resins were described by T. Hirotsu, *et al.* of the Government Industrial Research Institute, Shikoku; Research Institute for Polymers and Textiles, Tsukuba; and Science University of Tokyo, who discussed the synthesis and uranium adsorption properties of a dihydroxamic acid-type of chelating polymer and by S. Usami, *et al.* of Toyama University and Kuraray Chemical Company, Ltd, Bizen, Okayama, who presented their study of resins containing ethyleneimine and maleic anhydride. Other types of adsorbents were

discussed by C. K. Yun and C. K. Choi of the Korean Advanced Institute of Science and Technology, who tested galena and found that only 16 μg U/g ads could be recovered; by I. Tabushi and Y. Kobuke of Kyoto University, who prepared macrocyclic compounds that mimicked the crystallographic structure of uranyl complexes; and by T. Sakaguchi, A. Nakajima, and Y. Suwa of the Miyazaki Medical College, who studied various biological substances: streptomyces immobilized in polyacrylamide, melanin, and gallotannin. For the last, they found the maximum adsorption capacity to be 1.65 mg U/g ads.

- Elution

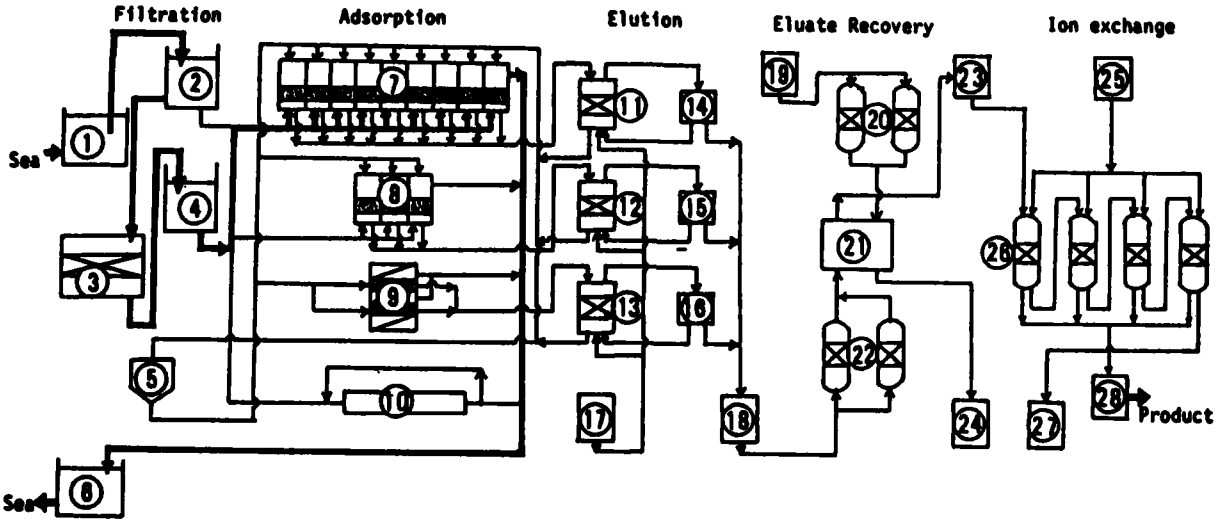
The problem of eluting uranium from the adsorbent was addressed in two papers. M. Suzuki, *et al.* of Tokyo University, Government Industrial Research Insititute, Shikoku, and Mitsubishi Chemical Industries Ltd., Yokohama, made an analysis of column elution and presented a mathematical model which gave a good prediction of column performance. A. Sasaki, *et al.* of Unitika Research and Development Center, Kyoto, and the Government Industrial Research Institute, Shikoku, used a glycine-N, N-bis (methylene phosphonic acid) type chelating resin and an anion exchange resin to separate uranium from acid eluates of polyacrylamidoxime resins. The flow diagram of their process by which they recovered 10 g of yellow cake from natural seawater is shown in Figure 2.

- Uranium Recovery Concepts

A variety of concepts and systems for recovering uranium from seawater were presented. J. Bitte, A. Kellener, and K. P. Ludwig of Uranerzbhergbau-GmbH, West Germany made cost analyses of four systems:

- a self-propelled, semisubmersible catamaran containing sorber,
- a moored catamaran containing sorber,
- fluidized sorber bed contained in a drifting ship, and
- fluidized sorber bed in a ship with vertical water intake.

S. Forberg, G. Lagstrom, and P. Vallandar of the Royal Institute of Technology, Stockholm, Sweden, described a wave-powered floating plant concept containing polyacrylamidoxime sorber and estimated that production costs will be in the range of $60-$135/lb. P. H. Koske of the University of Kiel, West Germany, and K. Ohlrogge of GKSS-Forschungszentrum Geesthacht GmbH., Geesthacht, West Germany, presented three papers in which they described a loop concept, for contacting seawater and adsorber; a pilot plant design based on this concept; and economics of the pilot plant design. In the loop concept adsorber granulate is carried along with the seawater to be processed in a loop-like configuration and is separated again from the water before it flows out of the adsorber unit (Figure 3). This concept enables considerably higher seawater velocities thereby permitting reduced bed area. Y. Masuda of the Japan Marine Science and Technology Center, Yokosuka, described a concept in which an adsorber net is affixed to a floating ship and wave energy is used to generate electrical power for pumping and processing. A very small scale test of this concept has been conducted. T. Yamamoto, H. Takase, and F. Fukuoka of Kogakuin University, Tokyo, presented a novel concept whereby uranium is adsorbed onto gel particles which are deposited on the sea bottom from where they are subsequently recovered. The gel particles consists of titanic acid, bentonite, and other coagulants. Slurry deposited at 100 m depths contains 7 ppm U.



1. Seawater intake pit
1. Seawater tank
3. Sand filer tower
4. Filtered seawater tank
5. Adsorbent tank
6. Effluent tank
7. A-type adsorption beds
8. B-type adsorption beds
9. C-type adsorption beds
10. Test waterway
11. A-type elution tower
12. B-type elution tower
13. C-type elution tower
14. A-type eluate tank
15. B-type eluate tank
16. C-type eluate tank
17. Eluent tank
18. Eluate surge tank
19. Fresh water tank
20. Filtration tower
21. Eluate recovery system
22. Activated charcoal tower
23. Eluate surge tank
24. Recovered eluent tank
25. Resign eluent tank
26. Ion exchange tower
27. Waste eluate storage
28. Product uranium solution

Figure 1. Process flow diagram of the demonstration plant being constructed in Niocho, Shikoku.

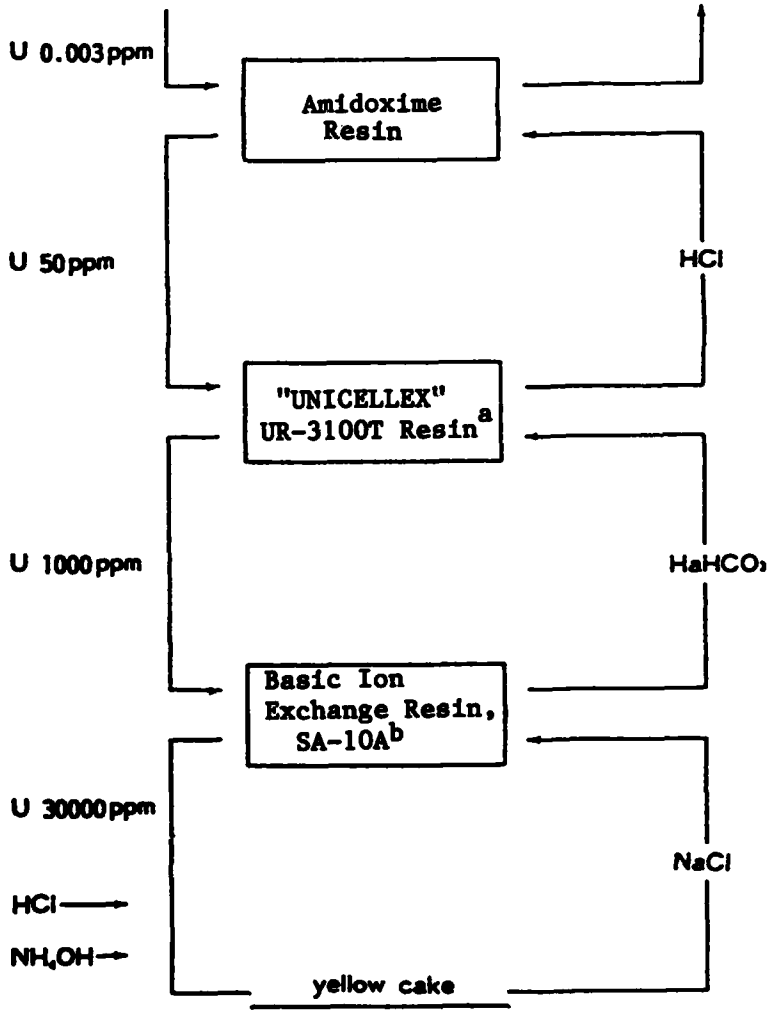


Figure 2. Flow diagram of uranium extraction process of the Government Industrial Research Institute, Shikoku.

a. Manufactured by Unitika, Ltd.,
b. Manufactured by Mitsubishi Chemical Industries, Ltd.

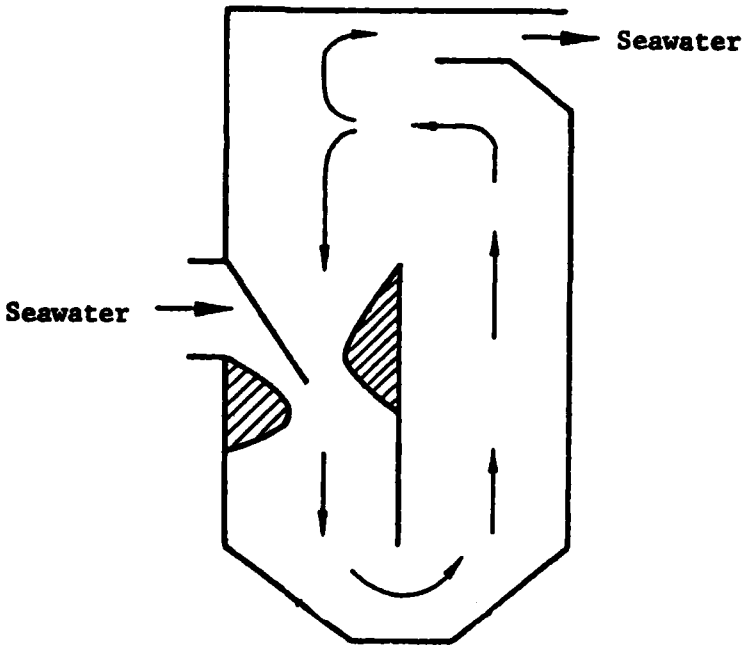


Figure 3. Adsorber loop concept, principle flow scheme; adsorber is carried along with seawater.

TABLE I

Comparison of the Characteristics of Hydrous Titanium Oxide (HTO) and Amidoxine Resins

	HTO	Resin
Adsorption capacity	B	A
Adsorption rate	B	B
Selectivity	C	B
Apparent density	A	B
Granulation	B	A
Physical strength	B	B
Chemical strength	B	B
Price	B	C

A=satisfactory, B=adequate, C=unsatisfactory

THE NOOPSYCHOSOMATIC MEDICINE OF HIROSHI TAKASHIMA: LOGOTHERAPY IN JAPAN

Paul Naitoh

INTRODUCTION

A significant Japanese contribution to clinical psychiatry has been known among American mental health professionals as the Morita therapy, which is a unique blend of Japanese philosopy with Western medicine. Morita therapy has often been used in the treatment of psychoneurosis. However, another significant Japanese contribution to the treatment of psychosomatic diseases by Hiroshi Takashima, a logotherapist in Japan, has been relatively unknown among American physicians and psychologists.

The purpose of this report is to describe the unique contributions of H. Takashima to psychosomatic medicine. After a brief biographical sketch of Takashima, the technique of "logotherapy" of Viktor E. Frankl will be introduced. Then follows a treatment of the relation of Takashima's concept of noopsychosomatic medicine to other theories.

Perhaps the best English introduction to noopsychosomatic medicine is via Takashima's book in English, *Psychosomatic Medicine and Logotherapy: Health Through Noopsychosomatic Medicine* (1977). Professional Western readers of the book probably will not understand the immense popularity of Takashima's writings among the average educated Japanese. Some of his popularity has resulted from the easy style of his two earlier volumes: *Treatment of Sickness through Gaining Purpose in Life - Living with Disease* (1974), and *You Can Cure Disturbances of The Autonomic Nervous System,* (1976). In 1981 Takashima published a technical but very easy to read book, *An Introduction to Noopsychosomatic Medicine: Bridging Medicine and Philosophy* (1981), which happens to be a Japanese translation of Takashima's 1977 book in English (mentioned above).

However, his popularity has its roots in his adoption of the German "Weltanschaung," which is to show "correct ways," as a guide for the Japanese to cope with life crises. By understanding noopsychosomatic medicine, Takashima hoped that his readers would not only learn more about logotherapy in Japan, but also would gain an overall understanding of the Japanese point of view in handling life crises.

BIOGRAPHICAL SKETCH OF TAKASHIMA

Hiroshi Takashima was born in 1912. He graduated from the Medical School of Nihon University, Tokyo, in 1935 with a M.D. degree. From 1935 to 1940 he worked as an assistant of internal medicine at St. Luke's Hospital in Tokyo. From 1938 to 1943 he was the director of his own hospital, and was honorary physician to the Italian Embassy in Tokyo, a consulting physician to the Brazilian Legation and the Chilean General Consulate in Tokyo as well as a special research worker at the Pharmacological Department of the Keio University School of Medicine. As a result of his work there, he was awarded a Ph.D. in pharmacology from Keio University in 1948. He has also been an occasional lecturer of internal medicine in many other Japanese hospitals and clinics. In the Western psychiatric world, Takashima has had major appointments in California, Connecticut, and other American centers of the logotherapy movement.

- Logotherapy

Perhaps the best general introduction to logotherapy is Viktor E. Frankl's *Man's Search for Meaning: An Introduction to Logotherapy*. Another Frankl work is *The Will to Meaning: Foundations and Applications of Logotherapy*, which is a more technical treatment for understanding logotherapy. Crumbaugh published a concise paper in 1965 which may serve as an introduction to the practice of logotherapy. In Frankel's 1973 book, *Everyting to Gain: A Guide to Self-fulfillment Through Logoanalysis*, he provided practical applications of logotherapy to counseling, alcoholism, and general clinical psychology.

Logotherapy or existential analysis is a psychotherapy based on a triad:

- the "meaning" of life through becoming creative,
- the "meaning" of life through experience, and
- the "meaning" of life through developing new attitudinal values.

The third element triad, "attitudinal values," is broken down into a triad of creating:

- "meaningful" attitudes to world pain,
- "meaningful" attitudes to world guilt, and
- "meaningful" attitudes to world death.

This triadic pattern of "pain, guilt, and death" is introduced by Frankl as the "tragic triad" of human existence.

Frankl believes that man has the unique ability to transcend his own environment, and to "decide what he wants to do," in the fullest sense of that term. Frankl's own experiences, and that of others such as the prisoners of Auschwitz, showed that man can transcend even the dire environment of a concentration camp and can still exercise effective coping behaviors and is still free to make up his mind in life situations. In terms of traditional philosophy, man has freedom of will. And man also has "Will to Meaning." Striving via the will to meaning is a key to much of higher-order motivation, and thus is a key to much of complex behavior.

Frankl recognizes that man can be free to will or to desire states other than meaningfulness. The logotherapy view is that human will (desire) has a hierarchical progression from the very basic will to survive, to the will to pleasure (labeled by S. Freud as the pleasure principle), to the will to power (as discussed by A. Adler), and finally to the heights of will to meaning. Takashima described this hierarchy in terms of an analogy of a life cycle reflecting the maturation of a complex organism. The will to survive is the fundamental activity of mind; it is easily observed in infants, and is commonly shared among all animals. The will to pleasure is perhaps most noticeable in the young while the will to power is most noticeable among the middle-aged. The will to meaning often becomes the most important motive for "mature and aged" individuals. Only man has the freedom to find meaning in what he is and what he experiences, and in what he chooses to stand for.

Frankl postulated that all life situations have meaning. Meaning in this sense, is roughly the same as a purpose in life. Each person seeks and finds meaning of life through his/her experiences, and various natural, esthetic, and human relationships. In facing the tragic triad of human existence (inevitable unavoidable pains, guilt feelings, and death), man can often discover nonobvious aspects of the meaning of life. For example, a meaningful attitude towards the tragic triad is created by exercising the

capability of detaching oneself from these tragical events of human life, or of forming new attitudes toward these events.

Such a detachment from and analysis of somatic and psychic phenomena implies a rising above their level and the opening of a new dimension, the dimension of noëtic (spiritual) phenomena, which can redefine and reinterpret biological events and personal experiences.

Thus, a clinical patient may "manage" himself by creating a new attitude toward his unchangeable fate or state. This activity is given the term of "psychonoetic antagonism by Frankl ("Die Trozmacht des Geistes"). In this context "Geist" translates to "spirit" to express the sense of "geistig," of being spiritual and mental--not the sense of "geistig" of being religious. It is possible for man to mobilize his own psychonoëtic antagonism or spiritual power to work against life's adverse forces; and it is possible for him to live satisfactorily with anxiety and tragedy even through these cannot be eliminated. A patient of Frankl, one Frau Kotek, who was suffering from terminal cancer, had actually recovered from a deep depression through finding "meaning" in her life, reportedly, she managed her life better even though she continued to suffer from cancer and eventually died from the disease.

To many critics, the "meaning of life" appears to be obscure and vague. However, the "meaning of life" can be defined operationally, at least to some extent. For instance, Crumbaugh's two paper-and-pencil tests, "the *Purpose in Life (PIL) Test*" and "the *Seeking* of Noëtic Goals Test (SONG)," are scoreable attitude scales. The SONG test was developed to measure the strength of motivation to find meaning of life, while the PIL was designed to assess the extent to which meaning in life has been found.

Logotherapy has its own psychotherapeutic methods which are derived more or less rigorously from the general hierarchical model of man. Two specific ones are "paradoxical attention" and dereflection (*contradistinction to hyperreflection).*

The paradoxical attention technique consists of breaking up a self-sustaining vicious cycle. For example, a phobic patient may feel anticipatory anxiety about entering a feared situation which increases his anticipatory anxiety, which in turn increases his fear. Clinical reactions toward a predicament may be either attempts to avoid the fear of fear (flight from fear, which develops into a phobic pattern), or to wish the feared event to happen, (in a case of an obsessive-compulsive neurotic). By the patient's paying attention to the very thing he fears-to-do or fears-to-see-happen, the patient stops fleeing from his fear and stops fighting his obsession-compulsion. A patient is assumed to be capable of detaching himself from this vicious cycle in order to see the consequences of the paradioxical wish: to see what he does not wish to see happen. Frankl calls the effective spiritual energy psychonoëtic antagonism: "This ability (to mobilize the psychonoëtic antagonism) is present in very human, since it is an essence of being human." However, Frankl realistically observed that the extent to which each patient can mobilize the psychonoëtic antagonism forces during paradoxical attention can vary widely from one patient to another. Thus, he called for care in applying the technique because it might psychologically break a patient if they can not meet the high demand for spiritual energy. Paradoxical intention is an effective short-term procedure to treat phobic and obsessive-compulsive symptoms. [It is contraindicated in psychotic depression to which Frankl recommends the dereflection technique (to be explained later).] For example, a patient may present a cardiac palpitation condition and will state a strong fear of losing consciousness. With the paradoxical intention model, the patient is told to make his heart beat faster in order to

make himself collapse. Of course, because of automatic safety provisions in the cardiovascular system an ordinary person cannot produce voluntarily the symptoms which would lead to unconsciousness; then, there is a good chance of breaking the neurotic cycle.

Dereflection is another logotherapeutic technique applicable to a patient fighting for something he wants (fight for pleasure), especially for sexual pleasures. For example, in a desperately heightened wish to obtain sexual potency and pleasures (hyperintention), a patient might focus a great deal of attention to his own sexual performance and experience (hyperreflection), which results in his attention being diverted "from the partner and whatever the partner has to offer in terms of stimuli that might arouse the patient sexually." Failures of adjustment due to hyperreflection leads to an accelerated degree of hyperintention, thus setting up another self-sustaining cycle. Dereflection techniques to teach patients to reduce the responses associated with self-defeating fights for pleasure. The technique of dereflection might be of aid in therapy against many forms of neurosis or mild psychosis. It does, of course, require a rather high degree of verbal skill and intelligence on the patient's part; perhaps some neurotics would perceive the advice as trivial or obvious.

- Takashima and Logotherapy

Takashima had developed his own concept of "living with disease" independently long before he met Frankl in Vienna in 1964. The living-with-disease idea had several similarities to Frankl's model: hierarchical scheme, emphasis on self-help, and personal integration.

After studying Frankl's works, Takashima refined Frankl's three-dimensional model of man by reexamining the somatic dimension. To Takashima, it should be further differentiated into structural and functional aspects. The structural somatic dimension represents those palpable aspects of our biological body, e.g., stomach, and other organs. The functional somatic dimension represents biological functions (such as processes of digestion) supported by biological structures (i.e., the digestive system of the stomach, intestines, etc.). This differentiation helped Takashima to understand human physiological diseases. Functional diseases are not necessarily caused by structural pathology though they can be somatogenic; that is, functional conditions can cause eventual changes in biological structures as the disease progresses. Hence, Takashima proposes that man has four dimensions; somatic (structural), somatic (physiological), psychological, and noëtic (or spiritual).

Takashima characterizes these four dimensions of the human being as body, function, psyche, and spirit or nous. Nous is a Greek word for mind but Frankl uses it as equivalent to mean, in German, geistig. For a typical passage, Takashima wrote that "the body is touchable, function is not touchable but made visible, the psyche and the nous are neither touchable nor visible, but conceivable." One difference exists between psyche and nous: psyche has no freedom, but nous does.

To explain how these four dimensions of man work together harmoniously, Takashima uses the analogy of an orchestra. The musical instruments represent the structural somatic dimension. The musicians' skills in playing the instruments correspond to the physiological somatic dimension, whereas the musicians' minds represent the psychological dimension, and the orchestras' conductor, the highest or noëtic level.

According to Takashima, if we explain the performance of the orchestra by saying that its success is nothing but the result of good musical instruments together with the skills and minds of the musicians, we are thereby reducing "the whole phenomena of the concert to less than its totality and are guilty of reductionism." The conductor, for example, plays a crucial role as he gives spirit to the orchestra. He alone can decide how to play the music within the limits of the orchestral score created by the composer.

Takashima develops the concept of psychonoëtic synergism, as the opposite of Frankl's psychonoëtic antagonism. In psychonoëtic antagonism, man mobilizes his spiritual energy to overcome the psychological aspects of suffering due to pain, guilt, and death. Takashima believes that the very same spiritual power can also work synergistically within psychological dimensions. He uses a sports example to illustrate the process: a person's desire to excel in sports, a feeling of shared responsibility toward teammates, and the determination to win a championship can all work synergistically with the psychological need to win. Such a model accords with the occasional surprising result where a team wins despite heavy odds against it. Takashima was himself a rugby champion, a short sprinter, and a high jumper. His experiences as an athlete were mobilization events of a personal type. Takashima also uses other examples of synergism, such as a patient suffering from pneumonia. When the patient realizes fully that he has social obligations and responsibilities other than just to himself and to his body, he may call on this psychonoëtic power to aid in overcoming the illness. When such spiritual power to live is present, the physical or pharmaceutical treatment of disease is more likely to be effective. On the contrary, in the absence of psychonoëtic synergism, unexpected and medically unwarranted deaths occur as was often reported in concentration camp populations.

Although Takashima embraces logotherapy in his practice of noopsychosomatic medicine, he interprets some logotherapeutic concepts from a specifically Japanese and Buddhist point of view. Takashima notes that Buddhists are often unwilling to engage in teleological arguments such as why men have two legs. People in the Western world are willing to ask the question of "why does man have two legs" as an acceptable question, and to look for an answer to it. The answer might be quite teleological: man has two legs because they were provided by nature. A Western-trained person might accept this "telelogical answer" and be satisfied with it. In contrast, a Buddhist might admit that he does not know why man has two legs as he feels that such knowledge is unknowable. However, a Buddhist might display an effective axiological awareness. Thus, the Buddhist would insist on learning how man uses his legs to the best advantage. To Buddhists, "life can be found only in the actualization of values that are inherent in our being in this world." In this axiological awareness, Takashima seems to have found a connection between Buddhism and logotherapy. In logotherapy, patients are asked to accept, with courage, their tragic life crises. They are taught to replace the question of: Why do I have to suffer so much? with a more productive question: How best can I live through my suffering?

Takashima has also [illegible]ed a logotherapeutic approach with the Buddhist's emphasis on "what is left," [illegible]hat is lost." When people in the Western world lose favorite possessions, they [illegible] themselves for carelessness or others for stealing. This over-concern or hyperr[illegible]ion with what is lost leads Westerners to a deep feeling of personal loss and depression. But both Buddhism and logotherapy are compatible with the idea that one should be grateful for one's remaining possessions.

Takashima quoted a Japanese word "akirame" which is often used in the everyday life of Japan. Akirame means to give up or abandon in Japanese, but it was derived from

the ancient Japanese word, "akirakame" which literally means to accept tragic life events by achieving a clear and full understanding of the unalterable and unavoidable nature of such events. Again the analysis can be handled confortably within a logotherapeutic concept.

Thus, Takashima believed that he had found a firm and common ground that stretched between Buddhism and logotherapy. His goal was to infuse more of Buddhism into the psychotherapeutic view of logotherapy, and thus to combine the best of the West and East.

The introduction of philosophical thought into clinical psychology and medicine did cause some controversy. Critics said that logotherapy represented a reversion toward philosophy, and that it was full of vague suppositions and obscure language. It was also observed that logotherapy incorporated a simplistic separation of mind and body, and could be only a naive and nonscientific psychology. Takashima's stance toward such criticisms was serene; as far as he was concerned philosophy was introduced only to bring humanity back to medical practice, and not to advance modern philosophical analysis. He accepts only as much philosophy as is necessary to create a humanistic approach to medicine.

Takashima's own writings has not remain relatively free of complicated abstruse arguments. The vagueness of language sometimes associated with logotherapy could perhaps be due to the difficulties of Martin Heidgger's existentialism with which Frankl and other logotherapies have long been related. For example, Frankl quoted, presumably with approval, the following lines that Heidegger wrote in a guest book when he visited Frankl's home:

> Das Verganene geht;
> Das Gewesene konmt.
> (What has passed, has gone;
> What is past, will come.)

Many words could be spent in the analysis of such assertions, but to Takashima, the above passage meant simply that the meaningless past is lost, but the meaningful past is stored forever. Takashima's interpretation clarifies the passage and probably salvages it, at least for the Western reader.

Some critics claim that logotherapy has adopted a simplistic dualism where humans are a dichotomy of an objective body and a subjective mind. Takashima attributes this criticism to a misunderstanding of the intent of logotherapists: their comments are made on the dimensions of human existence, are not to be treated as philosophically distinct entities, but rather are to be handled as the interrelated aspects of human beings.

- Logotherapy and Takashima's Noopsychosomatic Medicine

Takashima's personal convictions as a logotherapist are succinctly expressed by his statements:

> Medicine without science is powerless,
> Medicine without philosophy is meaningless,
> Medicine without humanity is soulless.

To him the essence of noopsychosomatic therapy is to consider patients in their wholeness as human beings. First, an extensive physical examination is given to confirm

that the major complaints received are truly psychosomatic. This prelude of a careful, detailed physical examination is regarded by Takashima, an internist, to be crucial. In his clinical experience, small undetected somatic lesions (such as the early stages of a bleeding ulcer) often add to the debility of psychosomatic disease. Such somatic lesions should be dealt with immediately before logotherapy is attempted. Thus, standard medical knowledge is essential in the practice of noopsychosomatic medicine.

However, Takashima argues that some aspects of medicine are not all yet scientifically based. For example, many diseases are not well understood. Detailed examination of referrals from internal medicine and surgery departments of many hospitals indicated to Takashima that these patients often were physically healthy in spite of their intense suffering. In other words, using currently accepted medical procedures, no evidence of any physical illness could be found among the referrals. And at another extreme, current procedures can identify the condition of terminally ill patients, but there are no standard ways to guarantee humanistic management of terminal or age-related degenerative cases.

One hallmark of noopsychosomatic medicine is found in the doctor's willingness to spend a much longer time with a patient, allowing him or her to talk at length about their medical and psychological condition. This leisurely approach is usually not possible for doctors who are busy with clinical consultations. It also appears that the practice of noopsychosomatic medicine requires an intense interaction with patients. Interactions are also found in psychoanalysis and in other therapies. In psychoanalysis, however, the patients are usually persuaded by the therapist to talk about subjects that they do not wish to talk about, whereas in logotherapy they are persuaded to listen to subjects about which they do not wish to hear. The anger helps to break the cycle which has been discussed previously.

A specific method which Takashima uses is called "living with the disease." For some psychosomatic ailnments such as stomach ulcers, pancreatitis, colitis, bronchial asthma, and rheumatism there are often no effective treatments, in the ordinary sense of that term. When patients are afflicted with such a disease, they instinctively fight to rid themselves of it. "Fighting against the disease" is an important factor in overcoming and being cured of many diseases states. In order to fight incurable diseases, the patient's life turns into a gloomy parade of one specialist after another and one hospital after another. Takashima cites the case of Mr. M. who was seventy-three years old. When Mr. M. was sixty, he began to feel pains in both knees. The condition was diagnosed as a mild form of chronic rheumatism. In the following two years, Mr. M. tried various remedies without relief. In desperation, Mr. M. sought the help of Dr. Takashima. Dr. Takashima recommended a medication to relieve the pain, and told Mr. M. to accept and "live with his rheumatism," without exhausting himself in looking for a nonexistent cure. After accepting Takashima's advice, Mr. M. regarded his knees as his friends. He told himself to be kind to his knees, since he has been a burden to them for seventy years.

Another example of "living with disease" is the case of Mr. T., a thirty-seven year old professor, who six years ago was diagnosed as having hypertension. After a dismal struggle with hypertensive drugs and regimens, he sought Takashima's medical advice. Upon examination, Mr. T.'s hypertension was found to be at an early stage which was quite manageable. Mr. T. was found to be healthy in all other respects. Since Mr. T.'s sufferings arose more from his dread of the disease and from his emotional exhaustion of fighting it, he was told to drop his unreasonable fear of hypertension and to come to terms with the disease. Takashima discontinued medication, with the provision that Mr. T. reduce his weight and take sufficient rest when tired. In a follow-up examination two

years later, Mr. T. was "living with hypertension," and his blood pressure was on the low side (without medication). He was found to be in good shape, both physically and mentally.

A critical question, of course, is to know when a patient should put up a fight against a disease, and when should he not put up a fight but decide to live with a disease. As a method of explicating this question, Takashima tells the story of "a snake and an ox" to the patient. Suppose, he says to the patient, that you are in a room with a small poisonous snake. You should try to kill it. In other words, the proper attitude toward a curable disease is to fight against it. Now, suppose that you are in a room with an ox, a gentle but powerful animal. The proper attitude toward a curable disease under this condition is to tame it, and not to try to overpower it. You try to live with the disease which cannot be cured by medical science. Takashima often uses himself as example of living with disease. He has only one of his lungs (the other lung, and several of his ribs have been surgically removed). The recommendation to whether a patient should try to fight or live with a disease must come from a doctor's scientific knowledge based on the odds of a cure, but a patient's willingness to follow through with a doctor's recommendation plays a critical role in its success rate.

Frankl's dramatic application of logotherapy has previously been given in the example of Frau Kotek, a terminal cancer patient with depression. Takashima provides the similarly dramatic case of Mr. Jun Takami, a well-known writer in Japan, as an example to show how much one can achieve by "living with disease." Jun Takami underwent an operation for cancer of the esophagus in 1963. The cancer reoccurred and he died two years later. During this two year period, he underwent four operations. His condition became critical five different times, but he survived all these crises. He died shortly after learning that his project of the Modern Literature Museum had progressed far enough for the official groundbreaking ceremony to be held. During the last two years of his life, he did not struggle against cancer. He "lived with cancer," and devoted himself to the work of founding the Modern Literature Museum. The courage to live with cancer had come from some "defiant power" of his general view of the world. Frankl believed that this defiant power (which can spring from psychonoetic antagonism) of the human spirit might have a life-prolonging or perhaps even life-saving effect; many logotherapists share his views.

The richness of his case histories, and their appealing simplicity, make Takashima's noopsychosomatic medicine attractive to other mental health professionals as well as to laymen. Although noopsychosomatic medicine still lacks a satisfactory theoretical foundation and a systematized doctrine, it provides abundant case histories of patients who have shown abrupt, significant, and enduring changes in their personal attitudes and value systems. Takashima himself has probably recorded more of these case histories than has any other therapist. Perhaps a future research undertaking in clinical psychotherapy would be to analyze more closely the components of a therapist's healing power. If Takashima and his logotherapist colleagues can heal, what are the components most responsible?

A CRITICAL EVALUATION OF NOOPSYCHOSOMATIC MEDICINE

There has been a massive lay interest and support of Takashima's noopsychosomatic medicine in Japan. He receives many requests for lectures, and his books and articles remain popular. However, the main logotherapy organization in Japan, which has been directed by Takashima, has only a small membership of a few dozen people and none of them are practicing physicians. Why this lack of general support from the Japanese medical profession?

One factor might be Japan's National Health Service Plan, which does not recognize the time-consuming aspect of logotherapy. Thus logotherapy, along with other forms of psychotherapy, is not yet fully integrated into the compensation system for Japanese medical field treatment.

However, the major factor which has inhibited the full acceptance of logotherapy by Japanese medical professionals could be widespread physician reluctance to accept Takashima's insistence that medicine without philosophy is meaningless, or that medicine without humanity is soulless. For most physicians with modern training, noopsychosomatic medicine can sound more like a new religion than a new contribution to science or medical practice.

Takashima is well-aware of this misunderstanding and he has been careful, as previously mentioned, to keep his language very direct and concrete. However, when he has to discuss man's craving for meaning and values, and man's anxiety and fear of becoming increasingly insignificant and interchangeable in this modern society, he believes that there is no alternative to introducing concepts such as the "noogenic" neurosis and the "existential vacuum" defined by Frankl and others. Takashima maintains that he incorporates philosophy into medicine in order to bring humanity back to medicine. His writings suggest that, to him, philosophy means a compassionate and rather common-sense study of human nature. Certainly by philosophy he does not mean the metaphysics of the mind-body problem, or technical investigations into the theory of knowledge.

Logotherapy and noopsychosomatic medicine have been strongly criticized by behavioral and experimental psychologists. Some critics feel that logotherapy represents an undesirable reversion to philosophy, from which psychology won its independence nearly a century ago. They also feel that logotherapy effects a simplistic separation of mind and body, and wallows in subjectivism, and lacks confirmable data that can lead to replication and correction of concepts. Takashima is well aware of these criticisms, and defends his viewpoint primarily from a clinician's position. As he sees things, logotherapy and noopsychosomatic medicine do not necessarily "regress" into religious questions of the purpose of life. In religion, the meaning of one's purpose in life is often given by God, whereas in logotherapy the purpose and meaning in life are searched for by the patients and found by the patients. Logotherapy does not dictate to patients what their purpose in life should be. If the patients happens to identify as their purpose in life that to be of a "religious" nature, then it is perfectly acceptable. Thus logotherapy and noopsychosomatic medicine have little to do with recommending one religious belief and faith over another. There is no doubt that Buddhism has influenced Takashima's outlook on the world considerably; but his Buddhism is accepted only as far as it provides for him a view of humanity. Certainly the success of noopsychosomatic medicine does not depend on faith in Buddhism. Perhaps the greatest asset of Takashima's noopsychosomatic medicine consists of its large number of case histories, and a treatment regime which is simple and caring and easy to understand. As with many verbal therapies, Takashima's approach seems to work best with those who are neither healthy nor really sick, but are simply aged or afflicted with incurable degenerative diseases. A few of the case histories from Takashima's files have appeared in print, but many of them remain to be systematized and published. It is also to be hoped that video or film recordings can be made available of Takashima's interactions with patients. Such materials would make the Takashima approach more accessible to the Western psychotherapeutic community, and would also permit a more definitive evaluation of effectiveness.

REFERENCES

"The application of logotherapy," Crumbaugh, J. C. *Journal of Existentialism, 5,* 403-412 (1965).

"Cross-validation of purpose-in-life test based on Frankl's concept's," Crumbaugh, J. C. *Journal of Individual Psychology,* 24, 74-81, (1968).

"Manual of instructions for the purpose in life test," Crumbaugh J. C. *Psychometric Affiliates,* Munster, Indiana, 1969.

"Frankl's logotherapy: A new orientation in counseling," Crumbaugh, J. C. *Journal of Religion and Health, 10,* 373-386 (1971).

Everything to Gain: A Guide to Self-fulfillment Through Logoanalysts, Crumbaugh, J. C. Nelson Hall, Chicago, 1973.

"The seeking of nöetic goals test (SONG): A complementary scale to the purpose in life test (PIL)," Crumbaugh, J. C. *Journal of Clinical Psychology, 33,* 900-907 (1977).

"Manual of instructions: The seeking of noetic goals test (SONG)," Crumbaugh, J. C. *Psychometric Affiliates,* Munster, Indiana, 1977.

"An experimental study in existentialism: The psychometric approach to Frankl's concept of noogenic neurosis," Crumbaugh, J. C. *Clinical Psychology, 20,* 200-207 (1964).

The Survivor, Des Pres, T. Oxford University Press, New York, 1976. *Man's Search for Meaning: An Introduction to Logotherapy,* Frankl, V. E. Pocket Books, New York, 1963.

The Doctor and the Soul: From Psychotherapy to Logotherapy, Frankl, V. E. Vintage Books (A division of Random House), New York, 1973.

Psychotherapy and Existentialism, Frankl, V. E. A Touchstone Book (Published by Simon and Schuster), New York, 1967.

The Will to Meaning, Foundations and Applications of Logotherapy, Frankl, V. E. New American Library, New York, 1969.

The Unheard Cry for Meaning: Psychotherapy and Humanism, Frankl, V. E. A Touchstone Book (Published by Simon and Schuster), New York, 1978.

THE JAPANESE BRAIN: THE TSUNODA METHOD

Paul Naitoh

Although today is ten days before the start of August, [crickets] chirping can already be heard [outdoors].

The Sound of the Mountain
Yasunari Kawabata

INTRODUCTION

Some Japanese scholars of Japanese literature may not agree with the interpretation of the above short sentence of Kawabata, a 1968 Nobel laureate in literature, but all would agree that to attach such significance to insects singing is part of the Japanese culture. They do not dismiss the "singing" as insignificant noise.

It will come as no surprise to the Japanese to hear that the chirping of crickets and the tinkling of the "bell ring" insect (*Homoneogryllus japonicus*) played a role in the study of the Japanese brain by Professor Tadanobu Tsunoda, an otolaryngologist at the Department of Auditory Disorders, Medical Research Institute, Tokyo Medical and Dental University, Tokyo.

One night, as Tsunoda was writing, with his study window open to let in some fresh night air, he experienced unusual difficulty in concentrating on his writing due to the sound of crickets. It seemed to him that the chirping kept intruding into his thoughts. He caught himself over and over again listening to the crickets. He was puzzled by these repeated and uncontrollable intrusions of the crickets chirping which interfered with his writing. How was it possible that the sounds of insects commanded so much of his attention? To clarify his problem, the next day he used what is now known as the Tsunoda method (to be fully described later) to examine how he was responding to the chirping. To his amazement, it appeared that the crickets singing was handled by the left hemisphere of the brain, the "linguistic" brain. This meant that of the events of the night before, the left hemisphere of the brain was processing the chirpings and the linguistic and logical thought necessary for writing simultaneously. Apparently, crickets were "talking" to him. This contest between the insects "talking" and the inner "speech" that is necessary for writing, only one of which could gain control of his left "dominant" hemisphere, consequently created difficulty in concentrating on writing the paper. Later studies have shown that the "Western" brain does not have this sort of problem because is processes the singing of insects through its nonlinguistic hemisphere.

What is Tsunoda's core theory? It can be compressed into the familiar argument of nature *vs.* nurture. Tsunoda maintains that the ways by which the human brain regulates the human body and mind are the same for the entire human race, however, the use of the left or right hemisphere of our brain is partly determined by the linguistic environment of where we were born and brought up. Tsunoda suggests that the structure of the Japanese language has molded the "Japanese" brain to operate in a way quite unlike the "Western" brain with regard to linguistic and nonlinguistic aspects.

An outline of the Tsunoda method and of its findings can be obtained from the reference works listed in the Appendix. However, a complete description of the Tsunoda method, one detailed enough to help set up replication experiments in a laboratory by interested scientists, is not yet available in English. Also not available to English-speaking scientists are many of the recent findings by Tsunoda.

In science, efforts of replication of previous works are made to corroborate findings so that these findings become accepted as scientific knowledge. This has been the motive for describing the methods of data acquisition and analyses so meticulously so as to increase the likelihood of others replicating the original findings. The replication of Tsunoda's findings would certainly be deserving of the efforts of other scientists. However, the details of the Tsunoda method must be made available in a language read by most scientists, i.e., English.

The objectives of this paper are twofold. First, it aims to report the details of the Tsunoda method so that American psychologists can attempt to replicate the experiments. A series of studies by W.A. Cooper and his group, at the Department of Audiology and Speech Sciences, Purdue University, will be discussed. Dr. Cooper and his group are the only English-speaking scientists, so far, who have attempted to seriously evaluate the Tsunoda method and its findings despite the existing information gap. Also two recent Japanese replication studies will be discussed, one of which was carried out by Ken Sato.

The second objective of this paper is to discuss Tsunoda's findings and his theory of a Japanese cultural trait. Tsunoda offers a "theory of mental structure and vowels" based on the brain's handling of vowel sounds. An often observed difficulty of the Japanese to communicate their ideas and wishes across the conference table in emotionally tense international negotiations may partly be explained by what Tsunoda regards as an "overloaded left hemisphere." An empirical basis to evaluate whether or not such a theory is scientifically sound will be offered in this paper.

The Tsunoda method consists of many data collection procedures. As such, we can not define what it entails exactly because it keeps changing by de-emphasizing older difficult techniques, and by additions of new ways to collect more reliable data, such as the recent addition by Tsunoda and his group of auditory-evoked potentials using electroencephalograms. Many new auditory stimuli have been added for use in the Tsunoda method. In this paper, the methodological discussions will mainly be limited to the two auditory stimuli of the /a/ vowel sound and the 1 kHz pure tone.

THE TSUNODA METHOD

The Tsunoda method is principally a behavioral test. One feature of the Tsunoda method is known as a "cerebral dominance delayed auditory feedback (DAF) key tapping" test.

The Tsunoda method has four modes:

- standard attention mode,
- nonattention copy mode,
- loading mode, and
- competition mode.

The Tsunoda method will be discussed in three sections:

- historical background on the development which led to the Tsunoda method,
- personal experience as a subject, and
- an example of one test session and overall descriptions of the Tsunoda method.

- Historical Background on the Development which led to the Tsunoda Method

The Tsunoda method has its origin in D.E. Broadbent's work in 1954 on immediate memory recall on two separate channels. Broadbent presented target digits to one ear, and different target digits to the other ear of a subject simultaneously. The subject was to recall the digits in whatever order he could manage the best (free recall). This is a dichotic listening task. Broadbent found that, given binaural lists of spoken digits, the subjects reported all digits presented to one of the ears before they reported those presented to another ear, i.e., "ear advantage."

Kimura discovered the value of Broadbent's method for examination of hemispheric specialization in two papers published in 1961. Kimura simultaneously presented spoken digits to one ear, and different spoken digits to another ear of brain-damaged patients. She found that patients with left hemisphere damage in the temporal region were able to recall fewer digits in comparison with control patients with right hemispheric damage. More importantly, she observed that the patients showed a right ear advantage in that they recalled more accurately those spoken digits presented to their right ear than to their left ear. Kimura also applied dichotic listening to study how a right ear advantage develops in children.

Further studies in the use of dichotic listening are discussed by Bryden and Allard (1978) in terms of the development of linguistic processing. For example, Studdert-Kennedy and Shankweiler (1970) used artificial words consisting of a consonant-vowel-consonant combination (CVC). The CVC "words" differed sometimes only in the medial vowel, in the initial of the terminal stop consonant. They found that consonants but not vowels induced a significant right ear advantage.

Independent of research efforts on dichotic listening, Fairbanks, in a 1955 paper reported that speech was seriously disturbed when the sound of it was delayed and fed back to the speaker (i.e., delayed auditory feedback, DAF), a maximal disturbance of DAF was found to occur when the delay is 0.2 seconds. Chase observed in 1959 that rhythmic key tapping was seriously disturbed when brief auditory stimuli were given after each tapping but with a short delay (i.e., delayed auditory stimulus, DAS). Those disturbances in speech were as great as those observed in speech patterns under delayed auditory feedback (DAF). This disturbance was observed when the auditory intensity of DAF was above one's hearing threshold. Hence, the DAF effect could be used objectively to determine the hearing threshold and this fact was developed into pure tone delayed audiometry; see, for example, Ruhm and Cooper (1962, 1963).

As early as 1965, Tsunoda combined features of a method of dichotic listening together with a key tapping approach under DAF to devise his new method.

- Personal Experience with the Tsunoda Method

. Personal Experience with the Attention Test

As a first step towards understanding data collection protocol, Tsunoda agreed to examine me so that I could experience some of the steps of the Tsunoda method used in screening a naive "subject."

First, I was instructed to tap a response pad with one finger of my preferred hand as fast as I could, yet maintaining a rhythm and with my eyes closed. Unlike an "advanced tapping" in a pattern of, say, 4-2 (.... pause ..) which would be used in the Tsunoda's method, I was asked to tap straight on without following a particular tapping pattern. After a while, I was asked to listen to 1 kHz tone pulses to both ears on a stereo

earphone. Each 1 kHz tone pulse was to be synchronous with each tap. My job was to keep tapping so that I heard steady rhythmic tone pulses, a task of sensory-motor integration of key tapping and listening.

Tsunoda in his 1980 paper mentioned that some persons were very poor in learning the sensory-motor integration necessary for examination by the attention mode of the Tsunoda method. Some of them depended more on the kinesthetic sensation of the touch of the finger which was doing the key tapping than on the tone beeps coming to their ears. Some had to count while tapping to keep it rhythmic. I was one of the poor "tappers" as I felt that the dual task of listening to "beeps" generated by my own key tapping and of making beeps rhythmic was difficult to perform. I was only able to tap rhythmically when I tapped slowly on the response pad.

After some practice, my next instruction was to attend to the tone beeps which came on with each tapping, and to ignore other auditory stimulus. I would continue to tap as fast as I could. I was told that the beeping tone to be heard with each tapping was indeed synchronous with the tapping (i.e., synchronous auditory stimulus, SAS). Other beeping tones were the same beeps only delayed (i.e., delayed auditory feedback, DAF; delayed auditory stimulus, DAS). Thus, I was instructed to ignore the DAS.

Tsunoda did not tell me which ear was going to receive the SAF throughout the test trial. Thus, I (and presumably any other subject) could not determine to listen with only one ear throughout the test trial but having to listen with both ears to the SAS. At the beginning of the test the DAS was weak, but the DAF became louder and eventually was loud enough to enter into my level of awareness. Then, I momentarily experienced a "spatially moving" tone, a "spatial disorientation" and confusion in deciding with which ear to "tap along." This confusion resulted in errors in tapping, i.e., long pauses between tapping.

This is Tsunoda's attention test mode in its simplest form. From what Tsunoda has reported in his papers, the task of attending to the synchronous sound (SAS) seemed not to be mastered by all of the naive subjects screened. To some musically oriented subjects, such as Mr. Koichi Watanabe, a longtime associate of Tsunoda, the attention task was not hard to master.

- Overall Description of the Tsunoda Method and Demonstration of Experimental Sessions

Details of the instruments used to produce the SAF and DAF for the Tsunoda method were given in English by Tsunoda (1975) and by Uyehara and Cooper (1980). Tsunoda's laboratory used a Nagashima Model AF1-B two-channel auditory feedback device. It produced a pure tone pulse of a duration from 50 to 70 msec, could change the delay time of auditory feedback from 0.125 seconds to 0.3 seconds, and it could generate many tapping patterns, for example, 3-3 (... pause ...), 4-4 (.... pause ....), and 4-2 (.... pause ..). Tapping was sensed by a flat response pad which could not only sense each finger contact, but also the magnitude of force of each tap. To produce the vowel /a/, first, a male speaker's voice was recorded on a continuous tape loop, then it was re-recorded on a cassette tape. The output from a cassette recorder was switched into the above mentioned Nagashima two-channel auditory feedback device when the vowel /a/ was needed instead of a pure tone.

Before the tapping test, the subject's hearing was tested at the 1 kHz tone through a stereo earphone, and the tone intensity was adjusted by 1 dB increments so that both ears would recline the same tone intensity. The subject was also supposed to practice tapping

to a set pattern of, for instance, 4-2 (.... pause ..) to such an extent that he could tap without conscious effort.

. Tsunoda's Attention Test Mode

After initially adjusting the intensity of auditory stimulus to be equal at each ear, the subject starts to tap with the help of the synchronous auditory feedback (SAF) given for both ears. Usually the duration of the SAS is 50 msec at an intensity of 40 dB Sensation Level (SL) or less (usually 20-30 dB SL is found optimal for many subjects). Then, after few seconds of tapping along with the SAF, one ear begins to receive a delayed auditory feedback (DAF) starting at an intensity level of 50-60 dB SL. Thus, the "attention" test mode of the Tsunoda method differs from the dichotic listening test: the Tsunoda method gives subjects the same auditory stimulus at different times, while the dichotic listening test uses different auditory stimuli at the same time.

The subject is instructed to disregard the delayed feedback stimulus. After a few seconds of tapping with the DAF, an experimenter switches the system back to give the SAF to both ears, and the subject continues to tap for few more seconds. This constitutes one trial, usually less than 20 seconds duration. Then, a paper recording of the subject's tapping responses is quickly scanned by an experimenter for "errors" in tapping. Errors are:

- an increased tapping interval,
- change in tapping speed or tapping force, and
- disturbed tapping patterns.

If the subject does not have any tapping errors, then the next trial is preceded by a few seconds of tapping with the SAF as before. The subjects tap for a few seconds under DAF with a higher intensity of, for instance, 5 dB SL followed by tapping under SAF again for a few seconds. The same procedure is repeated. When the subject continues to tap rhythmically and correctly, in spite of the DAF, a trial is repeated where the DAF intensity is increased in 5 dB SL increments until the DAF makes correct tapping impossible.

. Concepts of Ear Advantage and Cerebral Dominance

Let us use an example given by Tsunoda in his UNESCO paper (1981). Let us assume that we use the SAF at 30 dB SL throughout his hypothetical experiment. Let us assume further that a subject makes tapping mistakes when a 45 dB SL DAF is given to his left ear.

Let us label these quantitites for clarity of discussion:

$$x\,(R, SAS) = 30 \text{ dB SL}$$
$$x\,(L, DAS) = 45 \text{ dB SL}$$
$$d\,(DAS - SAS) = d\,(L\text{-}R) = 15 \text{ dB SL}$$

Now we reverse the procedure and give the SAF to the left ear, and the DAF to the right ear. Let us assume that this subject makes tapping mistakes when the DAF is at 30 dB SL. So using the above notation, now we observe:

$$x\,(L, SAS) = 30 \text{ dB SL}$$
$$x\,(R, DAS) = 70 \text{ dB SL}$$
$$d\,(DAS - SAS) = d\,(R\text{-}L) = 40 \text{ dB SL}$$

We note that this subject is able to "fight off" the DAS and to concentrate in tapping better when the SAS is given to the left ear.

That is, we form a difference of the differences:

$$D = [d(L-R) - d(R-L)] = 15 - 40 = -25 \text{ dB SL}.$$

The quantity "D" is then interpreted to show that this subject has a left "ear advantage" of 25 dB SL under the conditions of Tsunoda's attention test mode, and this left ear advantage is further regarded as showing right cerebral dominance.

A subjective report of the degree of difficulty in tapping was obtained after each trial, and it is consulted as collateral evidence for the presence of DAF effects on tapping. During the test the eyes of the subject are closed, and he is instructed to keep biting lightly on the molars.

An experimental session is now defined: one session usually consists of many short trials; and each trial lasts up to a period of 20 seconds out of which the first few seconds provides the baseline tapping performance under a binaurally presented SAF condition; then this baseline period is followed by a test period of roughly 10-15 seconds where the DAF is given to one ear; and finally the posttest tapping record of a few seconds is obtained. The trials are stopped as soon as the DAF effect on tapping performance is detected.

Many kinds of auditory stimuli are available such as the DASs and SASs used for the Tsunoda method, but usually a 1 kHz tone and the vowel /a/ are most often utilized for training and for archival studies.

. Precautions in Performing the Tsunoda Method

S. Miyakawa in his thesis (1981) indicated that three precautions should be taken in performing the attention test mode of the Tsunoda method in order to obtain reliable results.

First, the subjects should be instructed, as often as possible, to pay attention to the SAS during the test. Secondly, the subjects should be told not to read books, not to study foreign languages, not to drink alcoholic beverages and coffee, and not to smoke cigarettes starting several hours before the experiment as these activities are known to change the normal pattern of cerebral dominance. Thirdly, the subjects should have a period of rest between the experimental sessions which should be several times longer than the time spent in actual tapping because normal tapping is degraded by fatigue which brings about lowered level of attention in a long experimental session.

. A Demonstration of an Experimental Session for the Attention Test Mode

My request for a demonstration of the Tsunoda method with a seasoned subject was granted on 16 January 1981 at a laboratory in the Medical Research Institute of the Tokyo Dental and Medical University. Mr. K. Watanabe of the Nagashima Medical Instrument Company, Ltd., and a longtime associate of Tsunoda had agreed to demonstrate his DAF tresholds for the vowel sound /a/ and a 1 kHz tone, first using the attention" mode.

Since the session was simply for the purpose of demonstration and Mr. Watanabe's thresholds for the vowel /a/ and 1 kHz pure tone had already been established, some of

the normal measurement procedures were abbreviated. First, a tapping pattern of 4-2 (.... pause ..) was chosen. The duration of auditory stimulation was set to be 50 msec, and the delay time for DAF was set to be 0.2 seconds. The test started with the vowel sound /a/. Mr. Watanabe received 30 dB SL SAF in his left ear, and 50 dB SL DAF in his right ear. His tapping performance is shown in Figure 1-1. An imposition of 50 dB SL DAF resulted in an error to tap 3-2, instead of the correct 4-2 pattern. Also longer pauses could be seen between fours and twos. At the next trial, the DAF intensity was reduced to 40 dB SL. The tapping was judged still to be disturbed by the DAF because the pauses between the fours in tappings and the twos in the tapping were much longer than those seen during the baseline period. These disturbances can be quantified for statistical analysis as was done by Uyehara and Cooper in 1980. The test at SAF 30 dB SL/DAF 40 dB SL was repeated again to confirm that tapping performance was affected by DAF (Figure 1-3).

The DAF intensity was then decreased by 10 dB SL to test Mr. Watanabe at SAF 30 dB SL/DAF 30 dB SL. The effects of the DAF at this intensity were not clear (Figure 1-4). The DAF intensity was raised by 5 dB SL to test him at 35 dB SL DAF which resulted in a clear pattern error. Now the DAF was switched to the left ear, and the SAF given to the right ear, using again the vowel sound /a/. The first trial was with 50 dB SL DAF, which did not affect Mr. Watanabe's tappings (Figure 1-6). Tsunoda quickly increased the DAF intensity in steps (Figures 1-6 through 1-10) until he hit 85 dB SL to which Mr. Watanabe responded with an error. The session was stopped here with a summary:

- /a/ (R, SAF)=30 dB SL
- /a/ (L, DAF)=85 dB SL
- d (L-R)=55 dB SL.

Now, as we have done before, a formula of the differences would be:

- D=[d(L-R)-d(R-L)]=55-5=50 dB SL.

Mr. Watanabe did very well in tapping along the SAF given to the right ear, and he tolerated the delayed sound of the vowel /a/ as high as 85 dB SL to his left ear. This was the right ear advantage; in other words, the "left cerebral hemisphere dominance" for the vowel /a/. In comparison with the hypothetical example, the equation "D" showed direction of dominance: a positive "D" indicated left cerebral hemisphere dominance (or the right ear advantage), while the negative "D" indicated right cerebral hemisphere dominance.

Figure 2 show the results of the Tsunoda method using a 1 kHz pure tone with Mr. Watanabe as the subject. The session started with 1 kHz 30 dB SL SAF applied to the right ear, and 1 kHz DAF at 50 dB SL applied to the left ear which resulted in a disturbed tapping. Additional trials with different DAF intensities (Figures 2-2 through 2-4) showed that an intensity of 45 dB SL was the threshold to produce disturbed tapping. In short, we observed that 1 kHz (R, SAF)=30 dB SL, 1 kHz (L, DAF)=45 dB SL; d(L-R)= 45-30=15 dB SL. After a brief break, the 1 kHz DAF was delivered to the right ear and the 1 kHz SAF to the left ear. As before, the process was repeated until the threshold intensity which disturbed the tapping was determined. For Mr. Watanabe the result was:

- 1 kHz (L, SAF)=30 dB SL,
- 1 kHz (R, DAF)=75 dB SL,
- and d(R-L)=75-30=45 dB SL.

One kHz pure tone trials (Figures 2-1 through 2-9) showed that Mr. Watanabe was able to tap along better when the SAF was given to his left ear, i.e., the left ear advantage for the 1 kHz tone. Using a previous notation:

$$D = [d(L-R)-d(R-L)] = 15-45 = -30 \text{ dB SL.}$$

. A Demonstration of the Nonattention Copy Test Method

Tsunoda devised a nonattention copy test mode. In a trial involving the copy method, a subject is expected to tap a response pad whenever he receives an auditory stimulus through the stereo earphone. After a few seconds of tapping in response to an auditory stimulus, he begins to hear the same but delayed auditory stimulus in one of his ears. His task is to ignore this delayed auditory stimulus, DAS, and to continue tapping in the pattern of the auditory stimulus which he received in the initial trial. After a few seconds, the DAF is removed and only one and the same auditory stimulus is given to both ears. During the test, the intensity of the delayed auditory stimulus varies as it does in the attention test mode. The auditory stimulus is stored in one channel of a recorder, and the same but delayed auditory stimulus is stored in another channel of the recorder.

Since this test mode requires less attention than the originally devised method, Tsunoda called this test mode the nonattention copy test.

The results of the copy test with Mr. Watanabe for the vowel sound /a/, and for 1 kHz pure tone are shown in Figure 3 and 4. In the copy method using the vowel /a/, Mr. Watanabe started to tap whenever he heard the vowel /a/ at 30 dB SL. After a few seconds of copying, he heard the second delayed vowel /a/ at 50 dB SL in his right ear at 0.2 seconds after each vowel /a/ (Figure 3-1). In Figure 3-1, the time period of the DAS is given by a thickening of the time marker channel. The guide pattern of auditory stimulus which was to be copied is shown on the second channel. The tapping responses are shown on the third channel. A comparison of the tapping with the guide pattern immediately reveals the errors in tapping due to the DAS. For example, Mr. Watanabe's tapping became disrupted at 50 dB SL DAS. In the next trial, the intensity of DAS was reduced to 40 dB SL (Figure 3-2). Further trials seemed to show that Mr. Watanabe could tap correctly if he listened with his left ear and the DAS was at 35 dB SL. In the notation used above, the result was:

- /a/(L, SAS)=30 dB SL,
- /a/(R, DAS)=35 dB SL,
- d(R-L)=5 dB SL.

As in the attention test mode, Mr. Watanabe heard the DAS in his left ear. After five trials (Figures 3-5 through 3-9), it was found that Mr. Watanabe tapped correctly when he used the auditory stimulus heard through his right ear as the guide (cue) for tapping until the DAS became as loud as 80 dB SL. In other words:

- /a/(R, SAS)=30 dB SL,
- /a/(L, DAS)=80 dB SL,
- d(L-R)=50 dB SL.

Putting the results of the nine trials of Figure 3 together, D=[d(L-R)-d(R-L)]=50-5=45 dB SL (the right ear advantage); thus, the copy test showed that our subject, Mr. Watanabe, had a right ear advantage of 45 dB SL for /a/. This magnitude

of the right ear advantage was comparable with 50 dB SL right ear advantage observed with the attention test.

Figure 4 shows the result of the copy method applied to determine the ear advantage of the 1 kHz pure tone. Analysis revealed the left ear advantage of 25 dB SL for 1 kHz pure tone with the copy method, while the same left ear advantage of 30 dB SL was found with the attention test.

The results of the copy test appeared to be closely matched with those of the attention test. (Tsunoda, 1980, and Miyakawa, 1981). Miyakawa reported on six young Japanese subjects that the copy test mode for the vowel /a/ produced an estimate of 29.0 dB SL $\pm$ 9.1 right ear advantage, while the attention DAF test mode produced another estimate of 23.1 dB SL $\pm$ 6.0 right ear advantage. This difference is not significant (t=1.04, df=5; p=.346 two tails). The copy test mode for 1 kHz pure tone produced an estimate of 22.2 dB SL + 3.8 left ear advantage, while the attention DAF test mode produced an estimate of 17.5 dB SL $\pm$ 6.5 left ear advantage. The difference was again not significant (t=1.76, df=5; p=.139 two tails).

Tsunoda's subjects and patients judged that it was much easier to carry out the copy mode test than the attention test. The copy method also has added advantages. The analysis for errors becomes easier because the subject's response can be compared against the guide pattern generated by the test instrument. Also the copy method makes it possible for researchers to use any auditory stimulus. Tsunoda can now use any of the following sounds in the copy test mode of the Tsunoda method:

- verbal sounds: natural and synthesized vowels (e.g., /a/,/i/); consonants (such as, /ta/, /pa/); consonant-vowel-consonant sound, CVC, e.g., /doop/,

- artificial sounds: white noise; FM; AM; pulsed waves; two waves (F1 and F2) combined, where F1 is narrow band noise centered at 1 kHz, and F2 varies from 450 Hz to 2100 Hz; two waves (F1 and F2) combined, where F1 is fixed at 400 Hz, and F2 is 5% (maximum) frequency modulated around its center frequency of 800 Hz,

- emotive sounds: humming, laughter, cries, sighs, snoring,

- insects and animal sounds of the cricket, the bell ring insect, cicada, frog, sparrow, dog, cat, cow, chicken, lion; the natural sounds of wind and rain storms, breakers on the shore; the rushing of streams,

- mechanical sounds: the violin A, the A note played by an orchestra, temple bells, church bells, whistles, noises of helicopters, sounds of the Biwa (a Japanese musical instrument); traffic noises.

. A Description of the Loading Test Mode

The Tsunoda method can be used in other test modes than the attention and the copy modes, such as in the loading test mode, although its demonstration by Watanabe could not be obtained due to a limitation of time. Under this test mode, a bone conduction receiver is attached to the subject's forehead and tape recorded sounds are continuously played back into the receiver. The subject is continuously exposed to verbal sounds such as a vowel sound /a/ or a sound of a nonsense syllable /doop/ by the bone conduction receiver throughout the session. At the same time, the subject is instructed to perform

the copy mode of the Tsunoda test, such as listening to a 1 kHz pure tone to determine cerebral dominance. In other words, the subject is asked to perform a copy test while his or her brain is stimulated or "loaded" to do low level processings of a background acoustical event. Usually the intensity of this background acoustical event is varied from 20 to 40 dB SL, and the intensity of the SAS is fixed at 45 dB SL.

The subject is instructed, as before, to tap rhythmically as fast as he can ignoring the background verbal sounds, such as /a/ or /doop/, as well as the delayed auditory stimulus, DAS.

Instead of a bone-conducting receiver, the loading stimulus can be administered through the very same stereo headphone, which is used for Tsunoda testing, by means of a mixer. The mixer can combine the output of a tape recorder (to deliver a continuous background sound as auditory loading stimulus) with the SAS and DAS from the main test instrument.

The loading mode of the Tsunoda method determines how a background auditory loading stimulation affects the manner we normally process such sounds as a 1 kHz tone and the vowel sound /a/. Thus, to make the loading test work, the cerebral dominance of the subjects should be determined afresh on the day of the test before an additional auditory stimulus is loaded as the third stimulus. This step is made necessary by the fact that the cerebral dominance to SAS can be altered from the norm during the day of the test due to a subject's unintentional prior exposure to a foreign language, because of the subject's emotional disturbances, or because of the subject has drank either alcoholic beverages or coffee, or has smoked.

The background acoustical event is not limited to verbal stimulus (such as a tape recorded news broadcast in English), but it can be any continuous stimulus such as the chirping of insects or a 1 kHz pure tone.

Tsunoda observed that a lingustic loading of the left hemisphere alters the ear advantage. For example, as verbal stimulus (such as a tape recorded news broadcast mentioned previously), Westerners had a left ear advantage to the vowel sound of /a/, but under the linguistic loading with the /doop/ sound their response to the vowel /a/ shifted to a right ear advantage. That is, under circumstances where both hemispheres are activated by linguistic loading the Westerners start to handle the /a/ sound with their left hemispheres. This observation corroborates a statement by Cooper and O'Malley in their 1975 paper that "isolated vowels--may be able to trigger those mechanisms which cue the left hemisphere to recognize the incoming signals as candidates for special processing."

. A Description of the Competition Test Mode

This method is another variant of the copy mode of the Tsunoda method. No demonstration of this mode is provided in this paper. In other test modes of the Tsunoda method, the same stimulus is used for both ears, but one stimulus is delayed and it is fed back into one ear. In this competition test mode, however, both ears receive the delayed auditory feedback. Then the intensity of DAF is varied until it interrupts the tapping response. This test is not useful for determining ear advantage (i.e., the cerebral dominance). It is used to measure the intensity difference that is needed to disturb tapping under verbal *vs.* nonverbal DAS where the same auditory stimulus is used for SAS and DAS, but the same device can be arranged to give DAS which is different from SAS. The DAS would again be given to both ears. Since these two modes of the Tsunoda method

are not relevant for determining the cerebral dominance they are not discussed any further in this paper.

- Some Major Findings by the Tsunoda Method

. Language and Cerebral Hemispheres

Tsunoda found that right-handed Japanese and Polynesians tend to use the left hemisphere to process vowels both in isolation and in spoken words. Right-handed Westerners, Koreans, Chinese, and Bengalis handle isolated vowels with the right nondominant hemisphere, and they use the dominant left hemisphere only for vowels in a spoken context, that is, if they are used in consonant-vowel-consonent (CVC) form.

Pure tones were, however, handled by the right hemisphere in every case, Japanese or non-Japanese.

Tsunoda found that right-handed Japanese handle vowels with the left hemisphere because even isolated vowels have semantic meanings in the Japanese language. Tsunoda selected a few examples to show the large role played by vowels in the Japanese language (see *Kenkyusha*'s new pocket Japanese-English dictionary, 1964). They are:

- /a/: a mute; Dear me!; Ouch!
- /i/: the stomach; meaning; intention; medical; clothes; (count of) five; a well; a rank; take (a matter) to heart; strange; dignity; the Boar (one of twelve horary signs)
- /u/: a cormorant; the Hare (the fourth horary sign)
- /e/: a picture; a bait; a handle; an inlet; what?; Oh yes; "let me see..."
- /o/: a tail; hemp; a cord; a male.

Tsunoda maintains that the Japanese language forces the brain automatically to process vowel sounds first with the left brain (dominant and language hemisphere) because even isolated vowel sounds have semantic meanings in Japanese. This characteristic of the Japanese language is shared with the Polynesian language, but not with other large families of languages such as the proto-Indo-European family. Among Westerners isolated vowel sounds are first handled by the right hemisphere, and they are handled secondarily only when the vowels are in the context of language.

Tsunoda stresses that the Japanese brain automatically switches to the language hemisphere whenever a person hears isolated vowels.

Thus, as far as isolated vowel sounds are concerned, according to Tsunoda's theory, the physical use of our brain is determined by the first language we learn, the one we acquire from infancy. This has been described by psycholinguists (see, for example, the 1973 book by Brown). Whether we use the left hemisphere for processing isolated vowels depends not on the inborn physical structure of the brain, but on the linquistic and social factors offered by the first language we learn.

The physical structure of the human brain is the same for all races, but the same physical brain is used differently according to the linguistic environment. Previous to this startling observation by Tsunoda of a linguistic determiner of the use of the brain, the flexibility of the brain had been observed in the gradual taking over of the speech function by the right hemisphere after one's left hemisphere has been damaged. Tsunoda was the first to discover that the language we learn changes the physical operation of the brain.

In his 1981 UNESCO paper, Tsunoda described his surprise in 1972, when he first tested a non-Japanese, and a French national, purely by chance, and found a difference in the pattern of cerebral dominance between the French national and the Japanese as measured by the Tsunoda method.

In further studies, he reasoned that if the brain pattern is molded by linguistic environments then second- and third-generation Japanese, who had been born and brought up using Western languages should exhibit the Western brain pattern, and furtner that the children of Americans who were brought up in Japan using the Japanese language from birth should show the Japanese brain pattern. He defined the Japanese brain pattern to be: handling of the isolated vowel sounds by the left hemisphere, and handling of a pure tone by the right hemisphere. The non-Japanese Western brain pattern was defined as that the processes both isolated vowels and pure tones by the right hemisphere.

Nine second-generation Japanese, born either in Brazil, Peru, or the United States and who spoke Portguese, Spanish, or English were examined. They all reveal a typically Western brain pattern, except one. The exceptional case was a female whose linguistic background revealed that she spoke, read, and wrote only in Japanese until the age of 10, and then she emigrated to Brazil. At the time of the test with the Tsunoda method she was 26 years old, and her main language was still somewhat imperfect Portguese. This case, together with many other cases, led Tsunoda to speculate that the linguistic brain pattern with regard to the vowel sounds is established during the first nine year period of learning the spoken language while the brain maintains plasticity to linguistic environments.

Other observations of Tsunoda suggest that parents are only one of the environmental forces determining the linguistic brain pattern. An example cited by Tsunoda is the case of two sisters born in Japan to white American parents. Their father, a well-known researcher in U.S.-Japan relationships, was born in Japan to American parents. These two sisters were educated at a Japanese kindergarten and a Japanese elementary school. They played with Japanese friends at school. At their home, English was spoken, but they often spoke in Japanese. They spoke Japanese fluently with a Kansai dialect. At the time of the test with the Tsunoda method they were 27 and 26 years old, and their rank order in preference for the use of language was English and then Japanese. Tsunoda found that their brain patterns were completely of the Japanese type. Thus, it is speculated that, all linguistic brain patterns are not fully determined by hereditary endowment, but by the exposure to a linguistic environment before the age of 10.

In his 1981 UNESCO paper, Tsunoda summarized some of his studies on how the Japanese handle vowel sounds. A group of ninety-two subjects covered in Tsunoda's 1968 study revealed the following:

- sixty-six subjects (71.7%) showed right ear advantage or the left hemisphere dominance for 50-75 msec steady state /a/ vowel,
- seven subjects, or 7.6%, showed a reversed pattern of the left ear advantage to the vowel sound,
- seventeen subjects, 18.5%, showed no ear advantage, and
- two subjects, 2.2%, showed an unbalanced pattern.

Tsunoda's 1977 study involving 35 Japanese similarly showed an average right ear advantage of 18.4 dB SL to the vowel sound /a/. In 1980, a group of 45 Japanese were tested hearing the vowel sounds /a/. They showed an average of 26.7 dB SL right ear advantage. In this 1980 study, the right ear advantage of 27.8 dB SL was established for the female spoken /ta/ sound.

Since the duration of the vowel sound, e.g., /a/, was short, the vowel sound was perceived as a nonverbal buzzing. Thus, the subjects were not aware of the nature of the auditory stimulus, but the brain was able to distinguish a perceived buzzing sound of /a/ from other nonvowel sounds.

. Replication of Tsunoda's Findings

Tsunoda's basic finding that the vowel sound /a/ is processed by the left (language dominant) hemisphere in the Japanese has been recently replicated by two independent researchers. In his 1981 thesis, Miyakawa found that 17 subjects of a group of 18 (94.4%) showed right ear advantage to the vowel sound /a/ using the copy test mode. An average right ear advantage for these subjects was 25.3 dB SL $\pm$ 7.4. Sato observed in his 1981 replication study using the attention DAF test mode that 12 subjects out of a group of 14 showed right ear advantage (85.8%) to the vowel /a/; one subject showed no ear advantage (7.1%). Thus, both Miyakawa and Sato were able to replicate Tsunoda's basic (and perhaps even controversial) observation about the vowel /a/.

. Phonetic Features of the Vowel, "Brain Switch," and Natural Sounds

For the Japanese, it seems, vowel sounds consistently result in right ear advantage, that is, left brain dominance. Study of the phonetic structure of the vowel has shown that it consists of a few bands of strong sounds formed by the resonance of oscillations of the vocal cords in the vocal tract. Thus, a spectral analysis of the vowel sounds (i.e., speech spectrograms or sonograms) show a few distinct spectrally peaked bands. The first, second, third and succeeding peaks are called the formants, and are represented by F1, F2, F3 and so on. According to Hattori as cited in Tsunoda's 1978 book, three initial formants found in the Japanese male voice are on the average of around 790 Hz (F1), 1180 Hz (F2), and 2750 Hz (F3). Similarly, G. A. Miller lists as typical of F1 and F2 of the vowel /a/ to be 750 Hz and 1200 Hz respectively (1981). The most critical feature of the vowel is that the formants F1, F2, and F3 are not harmonically related.

To examine the roles of the formants in creating vowel sounds, Tsunoda has altered the vowel sounds by filtering out some of the formants, and then he conducted tests to determine how the Japanese brain handled these altered vowel sounds. He found that if only F1 was left after a low pass filtering, it was handled by the nondominant hemisphere (left ear advantage); and if F1 and F2 were left after removing the frequencies above F3, the sound was handled as if it was an intact vowel by the dominant hemisphere. Sato (1981) was also able to replicate this observation of Tsunoda using the attention DAF test mode of the Tsunoda method.

Tsunoda concludes that the essential features of the vowel sounds are that:

- they have two or more formant structures, and
- the central frequency of these formants are not harmonically related to each other.

For example, an artificially produced sound that combines 0.5 kHz = 1.0 kHz $\pm$ 1.5 kHz handled is by the nondominant nonlinguistic right hemisphere, but a sound created by adding 1 kHz and 1.3 kHz is processed by the dominant hemisphere as if it were a vowel sound. He found that the Japanese brain is very sensitive to these bands of two or more sounds which are not harmonically related to each other. The Japanese brain seems to make an instantaneous "switch" of the hemisphere to be used as soon as it discerns whether the sounds have harmonic components (in which case, the brain switches to the

nondominant hemisphere) or nonharmonic components (in which case, the brain switches to the dominant hemisphere).

Tsunoda attested to the high sensitivity of the Japanese brain to the frequency ratio of components in sounds. For example, when a sound having its central frequency at 500 Hz with the bandwidth of 200 Hz is mixed with a second sound of similar bandwidth, but with its center frequency at 1 kHz, the resulting compound sound is handled by the nondominant hemisphere because these sound components are harmonically related. But when a 500 Hz sound component of this compound sound is frequency modulated, and when the FM exceeded 1.5%, then the compound sound is handled by the dominant language hemisphere because the "formants" are not harmonically related and resemble the phonetic structure of the vowels. Sonograms showed that many natural sounds, such as that of "sobbing, laughter, insect chirping, animal barking," (Tsunoda, UNESCO paper) and others, have a vowel-like structure of the nonharmonically related formants, or vowel-like structure due to frequency modulation.

This means that "the Japanese verbal brain is also dominant for humming, sobbing, laughter, and other human sounds; for calls of animals; for noises of raindrops, wind and waves; for sounds of Japanese musical instruments and most other sounds present in the surroundings."

. How Did Crickets and Cicada "Talk" to the Japanese? A Mystery Resolved.

At the beginning of this paper, it was mentioned that the chirping of crickets are processed by the dominant language hemisphere, thus interfering with the work of writing a paper. Such interference is caused by the fact that the phonetic structure of chirping resembles vowel sounds which the Japanese brain automatically processes in the dominant hemisphere.

. Linguistic Stress and Brain Pattern

A rigorous study of the normal Japanese showed that on the average they have the right ear advantage for the /a/ sound, and left ear advantage for the pure 1 kHz tone. This is the normal brain pattern for the majority of Japanese who have lived in the linguistic environment where people speak, read, and write in Japanese. This brain pattern among the Japanese is found to be highly stable. It does not change with mental fatigue.

However, linguistic stress is produced in Japanese who have lived in an environment where people speak, read, and write English and brings about a temporary alteration in the brain pattern. Tsunoda's own experience, from a two-week trip to Canada when he attended an international congress, showed that his response to a 1 kHz tone shifted from his right hemisphere to his left hemisphere during and up to one week after his return to Japan which produced an unbalanced brain pattern with both the vowel sound /a/ and the 1 kHz pure tone. This pattern was neither characteristic of the Japanese nor of the Westerns.

Tsunoda conducted a test with 12 Japanese subjects who studied English for more than six years. They were asked to listen to an English language tape for 30 minutes, or to take dictation, or to read a text silently. All subjects showed a transient shift of a 1 kHz tone to the language hemisphere.

Miyakawa replicated Tsunoda's finding on a small group of three subjects (1981). All three subjects showed the usual left ear advantage of the 1 kHz tone, but a change to the right ear advantage when a 1 kHz tone occured when they were exposed to English as a background stimulus during a copy task, i.e., loading test mode.

In Tsunoda's study, four subjects listened to English conversation teaching materials for a total of 20 minutes in blocks of five minutes. The shift from the left to right ear advantage using a 1 kHz pure tone was observed shortly after five minutes of listening to English conversation. On the average, it required 90 minutes from the end of the lesson to revert to the Japanese brain pattern. One of the four subjects in this study was an expert trained in simultaneous Japanese-English translation, but he showed a similiar shift even in response to the simple English conversation used in the test.

For the average Japanese, the brain pattern does not shift to the Western brain pattern during or after a period when they use Western languages. Rather their brain patterns become degraded and unbalanced Japanese brain patterns in that the vowels, consonants, and tones are all processed by the dominant language hemisphere.

Tsunoda reported that this unbalanced brain pattern was accompanied by an unpleasant feeling and headaches, sure signs of linguistic stress.

. The Left Hemisphere of the Japanese Brain becomes Overloaded with Several Transactions

The Tsunoda method shows that the left hemisphere of the Japanese brain is engaged in many more transactions than that of the Westerners. Figure 5 summarizes the results of many studies.

In contrast to an overloaded language hemisphere of the Japanese, the Westerners language brain is clear of all of this congestion. In the Westerner's brain only consonants and verbal sounds of consonant-vowel-consonant (CVC) were handled by the left hemisphere.

Tsunoda pointed out that the Japanese would notice, without conscious effort, the chirping of crickets overlayed by the massive noises of a city. This is because crickets were "talking" to the Japanese through their language hemisphere while the urban noises were neatly shunted away assigned to the nonlanguage hemisphere of the Japanese. To a Westerner's brain, the chirping of crickets are assigned to the nonlanguage hemisphere along with other urban noises. Thus, the Westerners would have a very hard time noticing the chirping of crickets when they are exposed to so much other noise.

. Language Hemisphere and Emotion

Observations of neurological patients with hemispheric damage, of patients receiving unilateral electroconvulsive therapy, of patients going through the sodium amytal test of Wada, (see Wada and Rasmussen, 1960 for details) for determining language hemisphere, and of schizophrenic patients all suggested that each cerebral hemisphere controls a different overall emotional state. Flor-Henry in 1979 wrote a review on the rather complex nature of such control.

Tsunoda and Oka performed the Tsunoda test along with Wada's method. They observed that 34 Japanese cases showed euphoric reactions after injections of sodium amytal into the verbal hemisphere, and no reactions after injections into the nonverbal

hemisphere. Five cases showed euphoric reactions after injections into the language hemisphere, and depressive reactions to injections into the other side. The remaining five cases responded to injections to either side with euphoria. This result was quite different from what was seen among Italian patients. The Italians showed euphoric reactions after injections of sodium amytal to the nonlanguage hemisphere (Figure 5).

As noted previously, many natural sounds are found to have vowel-like phonetic structures, hence the Japanese brain handles them with the verbal hemisphere. Since many of the natural sounds such as human voices of humming, laughter, and cries evoke emotion it can be argued that the Japanese verbal brain is associated more with the control of emotions than the Western brain. Observations appear to confirm this speculative argument.

Thus, the verbal dominant hemisphere of the Japanese brain is more involved in controlling the overall mood and emotional state than the Western brain.

According to Tsunoda, the fact that the verbal hemisphere processes linguistic perception, logical thinking, and emotion may result in making Japanese more susceptible to a thinking process imbued or even confused by emotions. He believes that the "Japanese are an emotional people which is indeed closely related to the way the brain functions as determined by language."

EVALUATION OF TSUNODA'S CORE THEORY AND FINDINGS

- Tsunoda's Core Theory of the Japanese Brain

In the Japanese spoken language vowel sounds are most likely to convey semantic meanings. Hence the Japanese brain tends to process vowel sounds through the verbal (dominant) hemisphere. Only Polynesian languages (e.g., Tonganese, Eastern Samoan, and Maori) share this pattern. In the Western brain, the vowel sounds are first processed by the nonverbal (nondominant) hemisphere.

When people are brought up using the Japanese language, the brain is sensitized to vowel sounds, and automatically switches to the verbal hemisphere whenever it discerns the phonetic structure of vowels. In other words, "genetic factors may be responsible for the lateralization of the speech function on the left brain in most people, but the dominant side of the brain for processing the sounds with phonetic structure of the vowels is entirely determined by the type of language the person acquired as a mother tongue by age eight."

Since many sounds of nature resemble the phonetic structure of vowels (that is, the formant structure), they are processed by the verbal hemisphere. As many of these natural sounds are associated with emotional expressions, the verbal hemisphere of the Japanese is also involved in processing the emotional contents of the sounds and noises. Thus, the verbal (dominant) hemisphere of the Japanese brain tends to be overburdened and susceptible to emotional coloring on logical thought processes.

A CRITICAL EVALUATION OF THE TSUNODA METHOD AND THE RESULTS

Tsunoda's work has been regarded by some as a significant and unique contribution by a Japanese to establish a image of human beings whose mental functions are molded by "the mother tongue" as much as by genetic factors. However, some of Tsunoda's sweeping generalizations may invite skepticism and even foster a feeling that Tsunoda is more of a philosopher than a scientist.

The very basic difficulty of the Tsunoda method has been already alluded to at the very beginning of this paper--the lack of detailed information about how data are collected and then analyzed by Tsunoda and his associates. Although two Japanese researchers, Sato and independently Miyakawa, recently replicated Tsunoda's findings, the replication studies were slow in coming, even for Japan. Because of a lack of experimental details in papers published in English, Tsunoda's studies cannot be easily repeated by American and European psychologists and neuroscientists.

Recently, significant American efforts have been made to replicate Tsunoda's findings by a group of researchers at Purdue University headed by W. Cooper. Cooper and H. O'Malley used 24 young adult Americans as subjects using a 1 kHz pure tone and the vowel /a/ with their DAF instrument.

They could not find the right ear advantage to the vowel /a/ with these subjects. They found, however, that the delayed vowel sound to the right ear produces significantly larger mean time error in tapping than when a 1 kHz pure tone is used. This difference was interpreted to reflect functional auditory asymmetry.

In 1978, O'Malley critically reviewed the results of the 1971 paper by Tsunoda and Oka regarding a comparison of the Tsunoda method and the Wada test. His conclusion was that under the most generous interpretations of Tsunoda and Oka data they correctly predicted the sites of lesions in three of five patients, but that under a strict evaluation of these data he expressed "reservations about each of these cases."

More recently, in 1980, Uyehara and Cooper attempted to replicate Tsunoda's findings using 23 Japanese-speaking subjects and 23 English-speaking subjects. The Japanese-speaking subjects had learned Japanese as their native language, but no mention was made about each subject in terms of exact history and current condition of linguistic environment except that all subjects remained in their respective language environment up to the age of eight. Similarly, all English-speaking subjects were required to have learned English as their native language. Unfortunately no training history was available for individual subjects. The Tsunoda attention method was used employing the vowel /a/ and 1 kHz tone. Detailed statistical analysis failed to reveal significant auditory asymmetry with the Tsunoda's DAF key tapping task. Ueyhara and Cooper concluded that "the DAF key tapping task may not be a sensitive procedure to determine cerebral dominance for language among normals." The authors did not, however, deny the potential of the Tsunoda method for determining the site of a brain lesion.

Similarly an overall failure to replicate Tsunoda's findings with this method was reported by Sommerville in her Ph.D. thesis directed by Cooper.

A series of studies from Cooper's laboratory has been marked by excellence in experimental design, quantification of data, and statistical analyses of the data. By contrast, Tsunoda's work has been more "Skinnerian," a clinician who stressed detailed analyses of individual subjects but came short on quantification of data and their statistical analyses.

However, studies of Cooper and his group seemed to suffer from an apparent lack of an in-depth long-term look at the experienced research subjects to whom the DAF key tapping became second nature. Also their Japanese subjects did not enjoy the full cultural and linguistic environment created simply by living in Japan. Also the powerful effect of linguistic stress on the cerebral dominance pattern in the Japanese should not be overlooked. There seem to be many other factors that can mask the brain patterns as

reported by Tsunoda. Some of these factors are known to alter the ear advantage of the 1 kHz tone:

- mouth movements and speaking,
- smoking and smelling the aroma of perfume or ethanol,
- drinking coffee or alcoholic beverages,
- holding one's breath, and
- taking sleeping pills or minor tranquilizers.

The purpose of this paper on the Tsunoda method was to stimulate American psychologists and neuroscientists to study cultural (linguistic) determiners in physical uses of the human brain.

Tsunoda's "theory of mental structure and the vowels" presents the overall point of view that "spiritual structure" is based on the brain's manner of handling the vowel sounds. Of course, he does not mean that the Japanese culture is completely determined by the Japanese language. As Tsunoda has pointed out, the Japanese and Polynesians do have the same functional pattern of the brain in handling vowel sounds but the cultures differ significantly.

Tsunoda's theory deserves further validation effort.

NOTE:

Tsunoda collected his numerous studies on the Japanese brain into a book published in 1978. Unfortunately, this book has not yet been translated into English. The best technical paper in English on the "Tsunoda method" was his 1975 paper which appeared in *Brain and Language*. The most succinct and lucid summary of Tsunoda's research on the Japanese brain was the 1981 paper, read by him at a "Symposium to Examine Scientific Theories Invoked to Justify Racism and Racial Discrimination" held in Athens, sponsored by the United Nations, Educational, Scientific and Cultural Organization (UNESCO).

His work was introduced to Americans through two nontechnical papers in English. In 1977, M.A. Bertin and E.A. Kearsley, both of them at the Office of Naval Research, Tokyo wrote a brief sketch on the Tsunoda method, *Bulletin*,*2* (1), *45* (1977). In 1980, *Science 80* published a highly readable article on Tsunoda's works by A. Sibatani, who explained how he came to write this article in his 1981 thought-provoking book, *The Japanese and Biology*. It is in Japanese, however.

Tsunoda himself contributed to the efforts to let his findings be known to English-speaking people. He wrote an article for the *Japan Foundation Newsletter* in 1978, but this article has not been accessible to most interested American researchers.

APPENDIX

REFERENCES

"Some effects of temporal lobe damage on auditory perception." Kimura, D., *Canadian Journal of Psychology, 15,* 156-165 (1961).

"Cerebral dominance and the perception of verbal stimuli." Kimura, D., *Canadian Journal of Psychology, 15,* 166-171 (1961).

Language and Speech. Miller, G. A., W. H. Freeman, San Francisco, California, 1981.

"A study on test of the cerebral hemispheric dominance as an auditory examination." Miyakawa, S., Thesis, Department of Engineering, Kyoto University, (1981) (In Japanese).

"Assumptions underlying the delayed auditory feedback task in the study of ear advantage." O'Malley, H., *Brain and Language, 5,* 127-135 (1978).

"Pure tone delayed auditory feedback: Effect of instructions." Raymond, H. A., and Cooper, W. A., *Journal of American Audiology Society, 3,* 229-234 (1978).

"Low sensation level effects of pure-tone delayed auditory feedback." Rühm, H. B., and Cooper, W. A., Jr., *Journal of Speech and Hearing Research, 5,* 185-193 (1962).

"Some factors that influence pure tone delayed auditory feedback." Ruhm, H. B., and Cooper, W. A., *Journal of Speech and Hearing Research, 6,* 223-237 (1963).

"Influence on motor performance of simultaneous delayed and synchronous pure tone auditory feedback." Ruhm, H. B., and Cooper, W. A., *Journal of Speech and Hearing Research, 7,* 175-182 (1964).

"Automatic processings in recognition of sounds." Sato, K., *Gengo* (Language), *10,* 68-76 (1981) (In Japanese).

"The Japanese brain: The difference between East and West may be the difference between left and right." Sibatani, A., *Science 80, 1* (8), 22-27, 84 (1980).

The Japanese and Biology, Sibatani, A. Kosakusha, Tokyo, 1981 (In Japanese).

"Hemispheric specialization for speech perception." Studdert-Kennedy, M., and Shankweiler, D., *Journal of Acoustical Society of America, 48,* 579-594 (1970).

"Tsunoda's method: A new objective testing method available for the orientation of the dominant cerebral hemisphere towards various sounds and its clinical use." Tsunoda, T., *Indian Journal of Otolaryngology, 3,* 221-229 (1969).

"Differences of the cerebral dominance of vowel sounds among different languages." Tsunoda, T., *Journal of Auditory Research, 11,* 305-314 (1971).

"Functional differences between right and left cerebral hemispheres detected by the key tapping method." Tsunoda, T., *Brain and Language, 2,* 152-170 (1975).

The Japanese Brain: Working Mechanisms of Brain and East-West Culture, Tsunoda, T. Taishukan, Tokyo, (1978) (In Japanese).

"The left cerebral hemisphere of the brain and the Japanese language." Tsunoda, T., *The Japan Foundation Newsletter, 6* (1) 3-7 (1978).

"Logos and pathos: Difference in the mechanism of vowel sound and natural sound perception in Japanese and Westerners, and in regard to mental structure." Tsunoda, T., *Journal of Dental Health, 28,* 131-139 (1978).

"Difference in the mechanism of emotion in the Japanese and the Westerner." Tsunoda, T., *Psychotherapy and Psychosomatics, 31,* 367-372 (1979).

"Characteristics of the auditory cerebral dominance in Japanese." Tsunoda, T., *Shinkei Kenkyu No Shinpo (Progress in Neurological Sciences), 24,* 671-681 (1980) (In Japanese with English abstract.)

"An evidence of auditory processing mechanism for complex sounds." Tsunoda, T., *Otologia (Fukuoka), 26,* 677-686 (1980).

"The mother tongue and right-left dominance in the human central auditory system." Tsunoda, T., UNESCO Symposium, Athens, Greece, 30 March - 3 April 1981.

"Cerebral hemisphere dominance test and localization of speech." Tsunoda, T., and Oka, M., *Journal of Auditory Research, 11,* 173-189 (1971).

"Lateralization for emotion in the human brain and auditory cerebral dominance." Tsunoda, T., and Oka, M., *Proceedings of the Japan Academy, 52,* 528-531 (1976).

"The effects of dichotic delayed auditory feedback/synchronous auditory feedback stimuli on rhythmic motor tasks." Sommerville, Unpublished doctoral thesis, Purdue University, October 1980.

"Hemispheric differences for verbal and nonverbal stimuli in Japanese- and English-speaking subjects assessed by Tsunoda's method." Uyehara, J. M., and Cooper, W. A., *Brain and Language, 10,* 405-417 (1980).

"Intracarotid injection of sodium amytal for the lateralization of cerebral speech dominance. Experimental and clinical observations." Wada, J., and Rasmussen, T., *Journal of Neurosurgery, 17,* 266-282 (1960).

"Dichotic perception: Evidence for right hemisphere dysfunction in affective psychosis." Yozawitz, A., Bruder, G., Sutton, S., Sharpe, L., Gurland, B., Fleiss, J., and Costa, L., *British Journal of Psychiatry, 135,* 224-237 (1979).

"Do you hear the singing of the cicadas?" Bertin, M. A., and Kearsley, E. A., *Journal of the Acoustic Society of America, 62,* 1061-1062 (1977). Originally appeared in the ONR Tokyo *Scientific Bulletin, 2* (1), 45-46 (1977).

"The role of auditory localization in attention and memory span." Broadbent, D. E., *Journal of Experimental Psychology, 47,* 191-196 (1954).

A First Language: The Early States. Brown, R., Harvard University, Cambridge, Mass. (1973).

"Dichotic listening and the development of linguistic processes." Bryden, M. P., and Allard, F., *Asymmetrical Function of the Brain*, Cambridge University Press, 392-404, (1978).

"Comparison of the effect of delayed auditory feedback speech and key tapping." Chase, R. A., *Science, 129,* 3353 (1959),

"Effects of dichotically presented simultaneous synchronous and delayed auditory feedback on key tapping performance." Cooper, W. A., Jr., and O'Malley, H., *Cortex, 11,* 206-216 (1975).

"Pure tone delayed auditory feedback: Effect of prior experience." Cooper, W. A., Jr., and Stokinger, T. E., *Journal of American Audiology Society, 1,* 164-168 (1976).

"Pure tone delayed auditory feedback: Effect of hearing loss on disruption of tapping performance." Cooper, W. A., Jr., Sokinger, T. E., and Billings, B. L., *Journal of American Audiology Society, 3,* 102-107 (1977).

"Selected vocal effects of delayed auditory feedback." Fairbanks, G., *Journal of Speech and Hearing Disorders, 20,* 331-346 (1955).

"On certain aspects of the localization of the cerebral systems regulating and determining emotion." Flor-Henry, P., *Biological Psychiatry, 14,* 677-698 (1979).

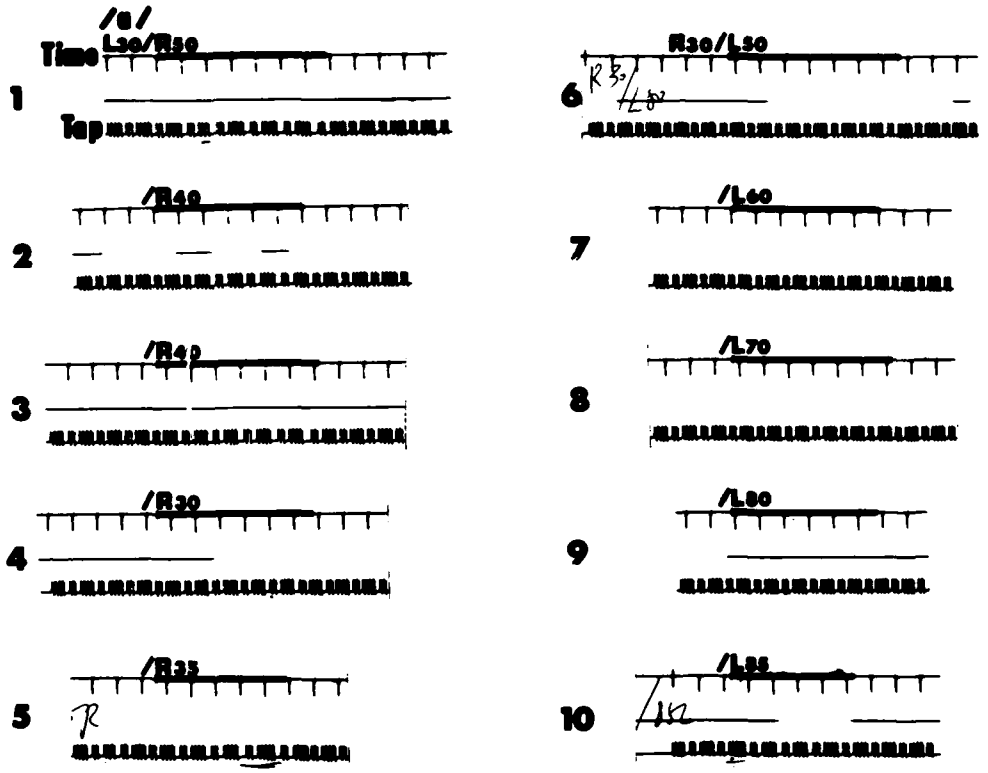


Figure 1. Results of Tsunoda method in "attention" mode. Time mark in seconds. Tapping responses are shown as pulses. Figures 1-1 through 1-5 : Synchronous auditory feedback (SAF) to the left ear, its intensity fixed at 30 dB SL. Delayed auditory feedback (DAF) given to an experienced subject, Mr. Watanabe, at 50 dB SL and DAF effect positive (+), twice 40 dB SL, + DAF effect positive, 30 dB SL and DAF effects now +, and 35 dB SL with + DAF effects, respecting Figures 1-6 through 1-10 show cases of SAF 30 dB SL to the right ear, with DAF intensity of 50 (negative DAF effects), 60 (-), 70 (-), 80 (-) and 85 (+), respectively auditory stimulus was the vowel /a/ sound.

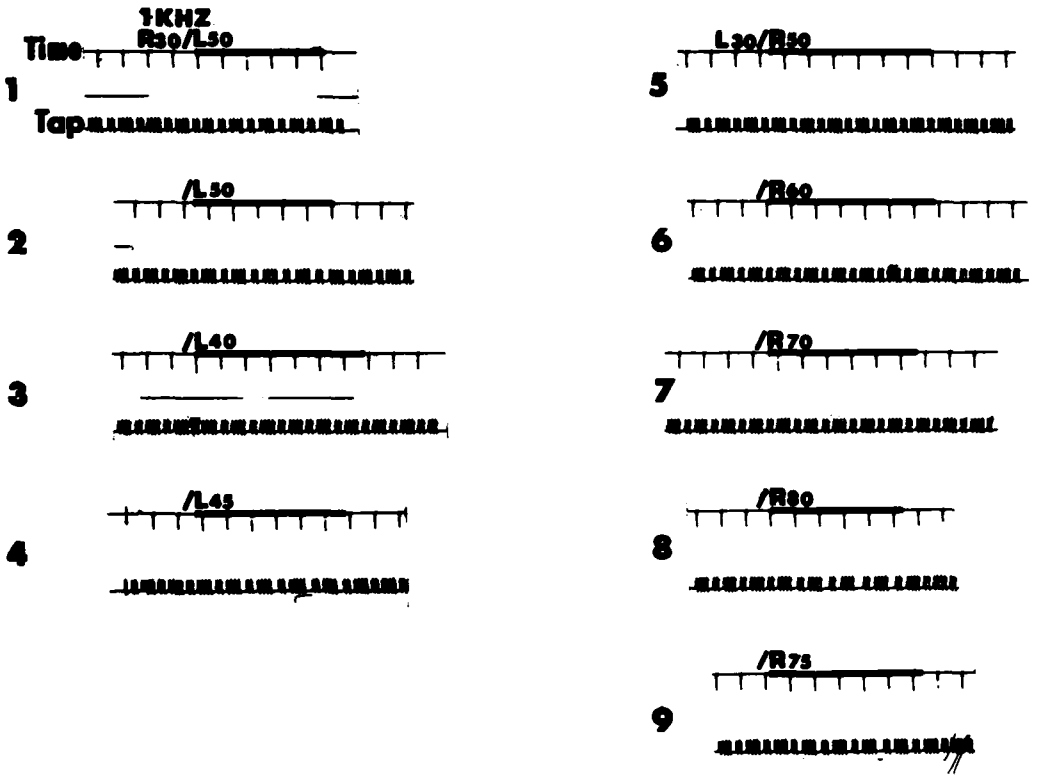


Figure 2. Results of Tsunoda Method used in "attention" mode. Auditory stimulus was a 1000 Hz pure tone. The test was started with SAF 30 dB SL to the right ear and DAF to the left ear, starting at 50 dB SL and repeated once more with positive DAF effects; DAF 40 dB SL (+ DAF effects); 45 dB SL (+ DAF). For Figure 2-5 through 2-9, SAF 30 dB SL to the left ear, with DAF to the right ear at 50 (- DAF effects), 60 (-DAF), 70 (-DAF), 80 (+DAF) and 75 (+DAF).

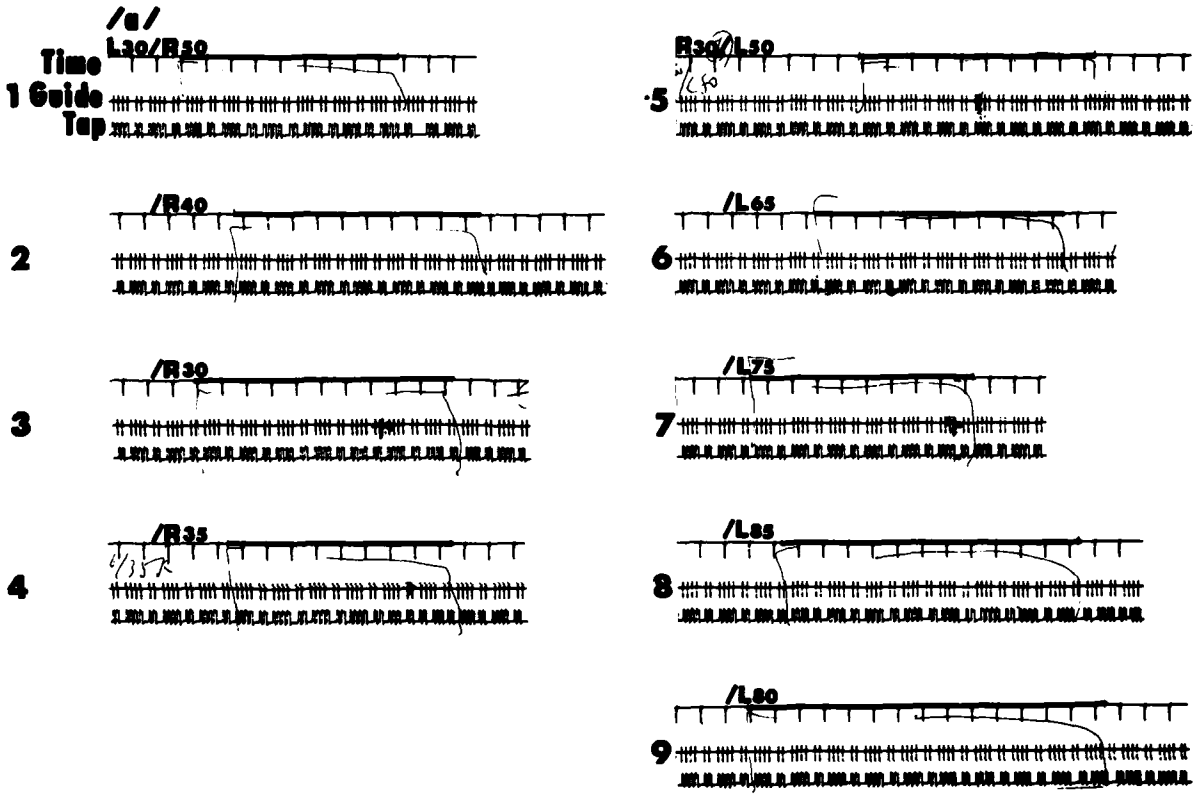


Figure 3. Results of Tsunoda Method using "nonattention copy" mode. Auditory stimulus was the vowel /a/ sound. For 3-1 through 3-4, SAF 30 dB SL to the left ear, and DAF to the right ear. DAF effects were +, +, -, and +, for 50, 40, 30 and 35 dB SL. Figure 3-5 through 3-9; SAF 30 dB SL to the right ear, and DAF to the left at 50 (-), 65 (-), 75 (-), 85 (+). GUIDE = Guide pattern given by the machine to prompt tappings.

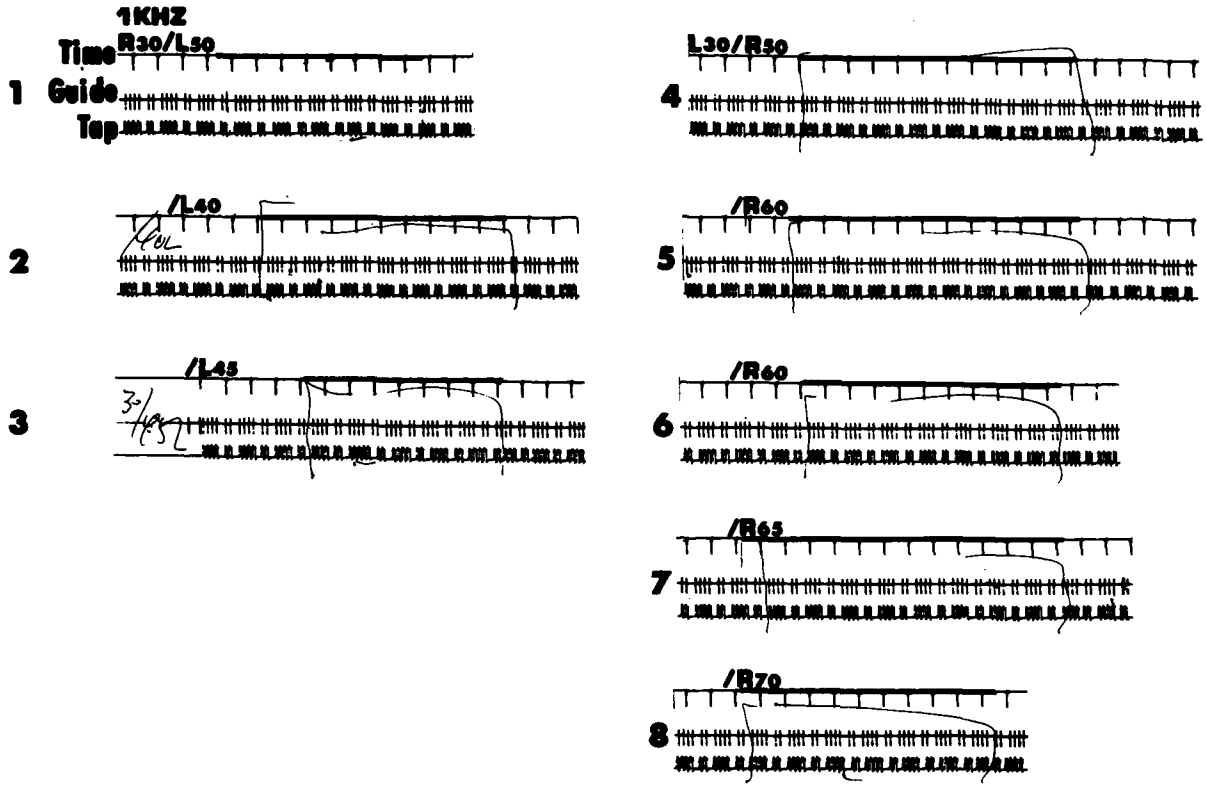


Figure 4. Results of Tsunoda method using "nonattention copy" mode. Figures 4-1 through 4-3; SAF 30 dB SL to the right ear, and DAF to the left ear at 50 (+), 40 (-), and 45 (+). Figures 4-4 through 4-8; SAF 30 dB SL to the left ear, and DAF to the right ear at 50 (-), 60 (-). 60 (-), 65 (+), and 70 (+).

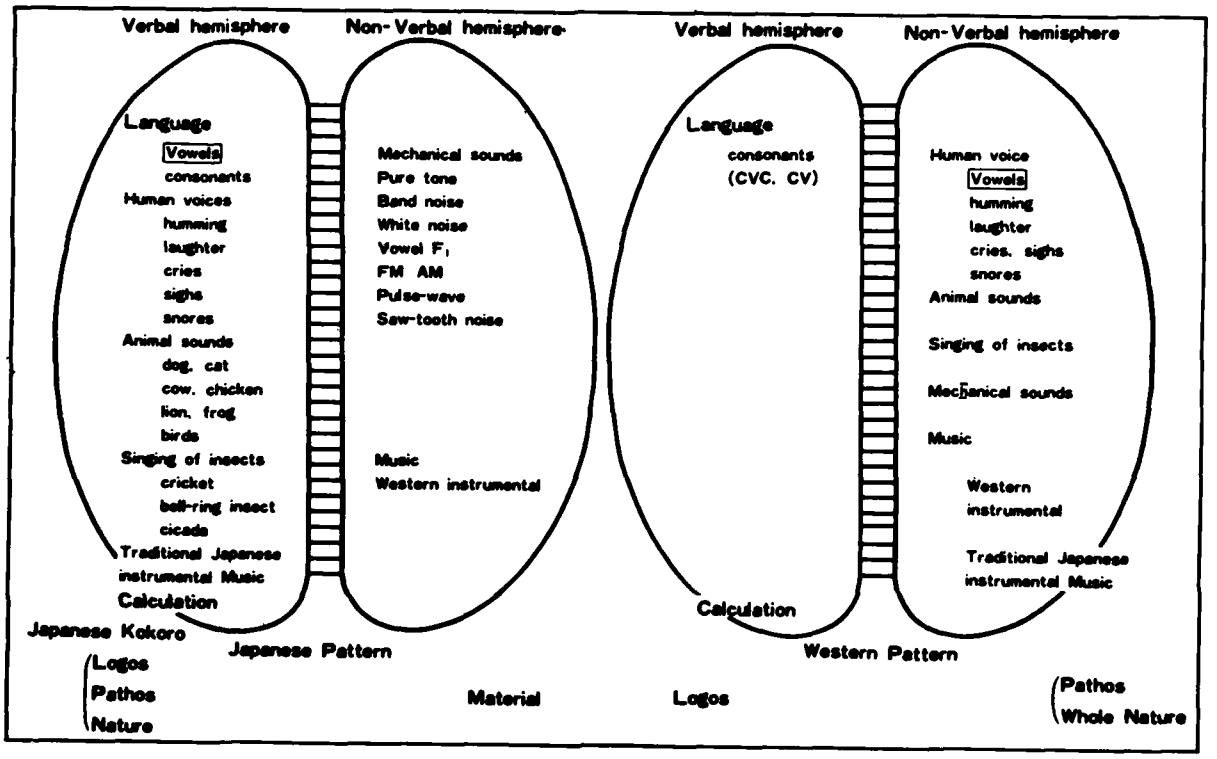


Figure 5. Differences between the Japanese brain and Westerner's brain, and their culture pattern. For details, see the text.

PRESENT STATUS OF POWDER METALLURGY IN KOREA

Duk N. Yoon

INTRODUCTION

The Republic of Korea (South) achieved remarkable economic progress during the last two decades with its GNP increasing almost 10-fold between 1968 and 1982. Industrial growth, as shown in Table I for selected products, during that period even surpassed the GNP growth rate. In order to meet the demands of electronics, machinery, automobile, and similar industries, powder metallurgy and related industries also expanded rapidly. This report is based on a recent survey and visits to powder metallurgy (PM) industries (including ferrites) in Korea.

The Korean PM industry began in the late 1960s without a prior technological base. A few firms began joint ventures with foreign (mainly Japanese) firms which provided the technology as well as the production equipment and raw materials. However, most of the firms were small and severely lacked technical capability. In the mid-1970s, many new firms sprang up to meet the growing demand within the country, and the resulting high competition for markets spurred a rapid progress in absorbing the technology. At the present, some tungsten and ferrite products are being exported.

As expected, the major PM products in Korea are the Fe structural parts and the oil-free bearings. Ferrite production has reached a substantial scale because of the electronics industry. Utilizing a relatively abundant tungsten resource (with estimated reserves of 6% tungsten ore deposition in the free world), large-scale production of W and WC powder was started in 1975. Presently, WC hard metals are produced for the domestic market and some are exported.

On the other hand, the production of other metal powders and capital equipment (such as presses and sintering furnaces) has been lagging due to a still limited market and a weak technological base.

POWDER PRODUCTION AND CONSUMPTION

Initially, in the PM industry, powders were imported. But in the mid-1970s, W and WC powder production was started on a large-scale from the ore available in Korea. Small-scale Cu powder production also began in the 1970s, and ferrite powder production in the early 1980s. Table II shows the major powder producers and their products. The total production capacity is 10,450 tons per year, the actual production in 1982 was about 5,000 tons.

Ferrite powder production increased rapidly in recent years because of the demand from the electronics industry for ferrite magnets and cores. Raw material was obtained from the Pohang Iron and Steel Mill which has an annual production of 10 million tons of iron and steel. The Pacific Metals Company began with the production of Alnico magnets in 1978 and started producing Ba ferrite powder in 1980 with technology imported from Japan. Upon reaching full production in 1982, it produced 5,400 tons, of which 1,200 tons were used for its own production of magnets, while 2,400 tons were supplied to the Korea Ferrite Company and 1,800 tons was exported to Taiwan.

Samwha Industry began production of Ni-Zn ferrite powder on pilot scale in 1981 and on mass scale in 1982 with the technology developed by the firm. The production in

1982 was 1,000 tons which was supplied to Samwha Electronics. The present production capacity is 3,000 tons per year, and the company is planning to double that in the near future.

The Korea Tungsten and Mining Company is one of the largest producers of W and WC powders in the world. After initially exporting scheelite concentrate, the company developed a technique for producing APT and began exporting it in 1973. In 1976, it began exporting W and WC powders produced with technology obtained from the U.S.A. The present total production is 2,800 tons of W of which 1,000 tons are exported as APT and 1,000 tons as W and WC powders. The major customers are companies in Japan, Europe, and the U.S.A. About 100 tons of WC powder (30% of production) is supplied to domestic firms. Recently, the company has developed filament-grade W powders and has begun to export them to Europe and other areas. The company is also planning to expand the production to ultrafine and ultracoarse-grade WC powders and is presently developing WC and TiC mixture powders. Its powder production technology has been considerably improved since the beginning of its own WC hard metals production in 1973, and it is putting much effort into developing many varieties of high quality W and WC powders.

Korea Nonferrous Metal Powder Company began producing sponge Cu powder in 1977 by an atomization-oxidation-reduction process which was developed in Korea. In addition to supplying Cu-Sn powder mixtures for oil-free bearings, it produces other nonferrous powders such as Al, Zn, Pb, and Al-Mg by atomization for domestic consumption. The Kwang Jin Industry began Cu powder production in the early 1970s. With a small-scale atomizer, it produces bronze powder for filter and other nonferrous metal powders. It has also been supplying electrolytic Cu powders for pantographs and carbon brushes.

About half of the Cu powder required for domestic consumption (about 200 tons) has been imported annually during the past few years (as shown in Table III). Since the mid-1970s, Cu powder for oil-free bearings has been imported from the U.S.A. and a small amount of Cu-Pb powder for engine bearings has been imported from Japan.

Since no Fe powder is produced in the country, all Fe powder is imported as shown in Table III. The amounts shown here include powder also used for welding rods. In 1977, for instance, about 700 tons (35% of total) were for PM products and the remaining 65% for welding rods. The rapid increase of Fe powder consumption between 1973 and 1977 was partly due to the increasing demand for welding rods used in shipbuilding. Powder metallurgy Fe powders are mostly imported from Sweden and powders for welding rods are imported from Japan.

With the recovery of the economy, powder production and consumption are expected to increase rapidly in the next few years. Automobile production, for instance, is expected to increase from the current level of 200,000 units per year to 500,000 units in the next five years, and the electronics industry is also expected to grow substantially.

TUNGSTEN CARBIDE HARD METAL PRODUCTION

WC hard metal production was started in 1967 by the Han Kook Metallurgy Industry as a joint venture with a Japanese firm and by Sinseu Industry. In the mid-1970s, the Korea Tungsten and Mining Company and many other small firms also began production of hard metals. Table IV shows major companies and their annual production. The demand for WC hard metals in Korea in 1982 was estimated to be 180 tons, of which 140 tons were produced in the country and 40 tons were imported.

Until the early 1970s, the firms mainly produced wear-resistant tools (such as drawing dies) and brazed tools, using sintering furnaces with hydrogen atmospheres. In the mid-1970s, vacuum furnaces were introduced and the range of hard metals production expanded. Presently, even some small firms have introduced vacuum furnaces and the total has reached to about 20.

In 1978, the Korea Tungsten and Mining Company, which is also a major producer of W and WC powders, began to produce WC hard metals and provided competition to the Han Kook Metallurgy Industry in the domestic cutting tool market. From that time, most of the demand for normal brazed tools and uncoated bites has been supplied from domestic firms. Recently, the Korea Tungsten and Mining company completed development of coated tools, which replaced some imported products. The Asia Hertel Company was established recently as a joint venture with a German firm and is equipped with modern facilities for production of high grade hard materials including coated tools. About ten other small-scale firms are concentrating mainly on wear-resistant tools.

At the present, the production capacity exceeds the domestic demand, but the export market can induce further expansion. The level of technology has been improved sufficiently to export some products to Taiwan, U.S.A., Australia, and other countries. The Korea Tungsten and Mining Company is planning to produce about 100 tons of granulated hard metals annually with a newly installed spray drier.

STRUCTURAL PARTS

The major companies producing structual parts are shown in Table V. The number of firms has increased rapidly from one in the early 1970s to five in 1975 and presently to 15 (including small ones). In 1975, there were only ten presses and five sintering furnaces, and today there are 60 presses and 30 furnaces. During the economic slowdown in the late 1970s, many firms were operating much below their capacity, and the ownership of some firms had to change because of financial difficulties. However, since the early 1980s, production has been steadily increasing.

The production of structural parts began in the late 1960s with a small-scale production of relatively simple items such as oil-free bearings and bushings. But the demand for Fe structural parts began to increase for automobiles and appliances, and in 1974 the Korea Powder Metallurgy Company installed a large production facility with presses imported from Germany. At about the same time, the Hyundai International Company (presently Mando Machinery Company), which has been assembling automobile parts, began to produce oil-free bearings, shock absorbers, ferrite magnets, and other parts. At this time, the Seoul Sintered Metal Company and Taigang Metals Industry (presently Daerim Powder Metallurgy Company) also began production. Most of the firms obtained production technology from Japanese firms, powder and equipment producers, and printed information. The Hyundai International Company, (presently Mando Machinery Company) at the beginning, received some technical assistance from the powder metallurgy R&D team at the Korea Advanced Institute of Science and Technology (KAIST). In 1980, the Orient Machinery Industry Company began to produce large PM parts with a 500-ton press, and more recently the Handok Powder Metallurgy Company was established.

In spite of a short history, the firms producing structural parts rapidly absorbed and improved production technology. Products have also become diverse enough to include those with Fe-Cu-Ni-Mo-C composition and 304 stainless steel. They are now able to

produce relatively high quality parts for appliances, automobiles, office machines, farm machinery, toys, etc. For sintering, mesh belt and pusher type furnaces have been the major facilities, but recently walking beam furnaces have also been installed.

The major structural defect these firms presently face arises from small-scale production of diverse products. A productivity decrease has resulted from frequent changes of pressing dies and other production line conditions. Although the total production is expected to increase, many firms may find it difficult to escape this problem. Therefore, some firms are investigating the possibility of technical collaboration with foreign firms to improve productivity and develop high quality products. At the moment, only Handok Powder Metallurgy (with Krebsöge of Germany) and Mando Machinery Company (with GKN of Great Britain) have technical assistance contracts with foreign firms.

FERRITE PRODUCTS

Ferrite production began with small firms in the early 1970s, and has been growing rapidly due to demand from industries such as audio and video electronics, automobile and motorcycle parts manufacturers, and communication equipment. Table VI shows the major producers and their production. The ferrite companies are presently operating at almost full production capacity.

In 1976, the Korea Ferrite Company began a large-scale production of anisotropic ferrite magnets. The total production, including the isotropic ferrites, has been steadiiy increasing largely due to exports which accounts for 65% of the total sales. The Pacific Metals Company also began production of anisotropic Ba ferrite in 1981 using powder produced by the firm. It has adopted a wet pressing technique in contrast to a dry pressing used by the Korea Ferrite Company. Although at the present the ferrite magnets produced are Ba types, the demand for Sr ferrite is expected to increase in the future.

Samwha Electronics Company, which began as a capacitor producer, installed a production facility for 600 tons of ferrite core annually. Beginning with deflection yoke core and flyback transformer core for television and other small cores of mainly Ni-Zn ferrite, it began producing, in 1979, E-type cores and toroidal cores of Mu-Zn ferrite. After a series of expansions, in 1981 it reached a 3,000 ton annual production capacity. Currently, 65% of the total production is Ni-Zn ferrite, but with a planned expansion of Mn-Zn ferrite powder production, Mn-Zn ferrite is expected to increase to about 50%. Other small firms produce about 600 tons of ferrite magnets (mainly Ba type) and 600 tons of ferrite cores (mainly Ni-Zn type) annually.

The demand for ferrite products is expected to increase further due to demands of growing electronics and computer industries.

OTHER PM PRODUCTS AND PRODUCTION EQUIPMENT

There are a few small- and medium-size firms producing other PM parts. Steel-backed engine bearings for automobiles, heavy machinery, and farm machinery have been produced since 1971. Currently, two manufacturers use about 60 tons of Cu-Pb and Cu-Pb-Sn powders per year. Five firms produce metal-bonded diamond tools and supply most of the domestic needs. For the metal binder, Cu-Sn powder is used for metal and stonecutting wheels, and W-Co powder is used for mining tools and bits. In addition, there are about ten firms producing bronze filters, brake discs, carbon brushes, pantographs, and electrical contacts. With an increasing demand for these products, quality has been steadily improving.

The supply of PM production equipment has also increased in recent years. Simple equipment such as screen mixers and ball mills are almost fully supplied from domestic sources, and pressing dies, including the hard metal-type, are produced mostly in the country. Simple hydraulic and mechanical presses are made for PM application, but most of the specialized PM presses are still being imported. Most of the batch-type furnaces, steam treatment furnaces, heat treatment furnaces, and ammonia dissociators are produced in the country, but continuous furnaces for PM and vacuum furnaces are mostly imported.

RESEARCH AND EDUCATION

Some R&D programs in powder metallurgy began in universities and research institutes in the 1960s before any industrial production had started. Powder metallurgy courses were introduced into university undergraduate curriculum in the 1960s and about ten universities now offer them. About four universities have active graduate education and research programs.

The research and graduate education at the Korea Advanced Institute of Science and Technology was started in the early 1970s and has developed into a large program covering basic and applied problems in PM. Its program centers around basic studies on sintering and grain growth with a liquid phase and production of W-base heavy metal, WC hard metal, Fe and Cu base alloys, and others. Five doctoral students and about 20 M.S. students have been trained in the program.

Hanyang University also has an active graduate program with a long history. It centers around activated sintering of W-base materials, contact materials, and WC hard metals. A large number of undergraduate and graduate students have been trained in the program and are active in the PM industry and research. Seoul National University and Chunnam National University also have graduate research programs but on smaller scales. The research results are reported in the *Journal of the Korean Institute of Metals* and in international journals.

The public research institutes (the Korea Advanced Institute of Science and Technology and the Korea Institute of Machinery and Metallurgy) are expanding development programs in PM. Among the industries, the Korea Tungsten and Mining company has built up a sizable research and development group which is contributing to the improvement of W-base powder and WC hard metal production.

FUTURE PROSPECTS

With the continuous growth of machinery and the electronics industry and availability of high level manpower, the PM and ferrite industries in Korea are expected to grow rapidly. The tungsten and iron oxide raw materials can also be utilized more fully. The domestic demand for structural parts is steadily increasing, but further improvement in productivity and quality will be necessary for rapid expansion into international markets. When the demand for Fe powder reaches about 5,000 tons per year, its domestic production is expected to begin.

Ferrite production is expected to maintain a rapid growth rate because of the demand from automobile, television, motorcycle, and appliance industries for domestic consumption and export. Production of high quality items such as Mn-Zn ferrite cores and Sr ferrite magnets are expected to show more rapid growth. The press and furnace makers are making an effort to increase their share of the market, which is currently dependent largely on foreign sources.

PM and ferrite industries are fairly technologically intensive and characteristically small- or medium-scale. Furthermore, they have a critical dependence on the raw material and production equipment industries. Therefore, they can present unique structural problems during their growing stages in a country like Korea. It will be helpful to assess more thoroughly the current status of the industry and make an effort to forecast for future development. The R&D and educational programs should then be closely linked to the development strategy of this industrial sector.

REFERENCES

1. *Economic Statistics Yearbook*. Korea Economic Planning Bureau, 1970-1982.

2. *Annual Report on Current Industrial Production Survey*. Korea Economic Planning Bureau, 1970-1982.

3. *Statistical Yearbook of Foreign Trade*. Korea Office of Custom Administration, 1973-1982.

TABLE I

Industrial Production in Korea[a]

Year	68	70	72	74	76	78	80	82
GNP per capita (10^2 $)	1.7	2.4	3.1	5.2	7.7	13	15	17
Electricity (10^9 kWh)	6	9	12	17	23	32	37	43
Steel (10^6 tons)	0.6	1.2	1.6	1.9	3.5	5.0	8.6	11.8
Copper (10^3 tons)	4	5	9	12	31	51	72	111
Automobiles (10^3)	17	22	15	47	50	157	121	164
Motors (10^5 hp)	0.3	3	2	5	9	20	13	17
Motorcycles (10^4)	1.6	1.3	0.9	1.1	1.7	7.7	11	12
Power tillers (10^4 hp)	6	2	10	24	35	45	55	73
Refrigerators (10^4)	0.9	2.6	3.3	7.8	22.4	105	67.6	98.5
Electric fans (10^4)	15	21	30	61	92	194	153	
TV Receivers (10^5)	0.5	1	3	11	23	47	68	60

[a] See References 1 and 2.

TABLE II

Powder Production in Korea

Powder Product	Powder	Capacity (ton/year)	Production (ton/year) 1980	1981	1982	Production start	Employee	Remarks
Korea Tungsten and Mining Co.	W	1000	940	1000	660	1975	140	export 50%
	WC	400	340	380	350	1975		
Pacific Metals Co.	Hard ferrite	5400	1200	2650	3000	1980	30	export 30%
Samwha Industry Co.	Soft ferrite	3000	-	-	1000	1980	30	
Korea Nonferrous Metal Powder Co.	Cu,Al,Sn Pb,An, Mg-Al	500	40	60	90	1977	30	
Kwang Jin Industry Co.	Cu,Sn,Zn	100	30	40	50	1973	20	
Total		10400	2550	4130	5150		250	

TABLE III

Iron and Copper Powder Imports into Korea[a]

(unit: metric ton)

Year	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
Fe	110	460	940	850	2090	1560	1850	2000	1920	2200
Cu	100	90	40	120	170	210	230	260	200	200

[a] See Reference 3.

TABLE IV

Tungsten Carbide Producers in Korea

Company	Capacity (ton/year)	Production(ton/year) 1980	1981	1982	Production start	Employee	Remark
Korea Tungsten and Mining Co.	60	30	42	50	1978	240	export (10 t/year)
Han Kook Metallurgy Industry Co.	60	40	46	42	1967	240	export (10 t/year)
Asia Hertel Co.	80	-	3	8	1981	80	
Sinseu Industry Co.	24	12	14	16	1967	130	
Shin Saeng Industry Co.	12	8	8	9	1978	110	
Others (7 Industries)	30	15	16	17	1971	300	
Total	266	105	129	142		1100	

TABLE V

Powder Metallurgy Structural Parts in Korea

Company	Capacity (ton/year)	Press		Sintering furnace		Production (ton)			Pro-duction start	Employ-ees
		Number	Max. Capacity	Contin-uous type	Batch type	1980	1981	1982		
Korea Powder Metallurgy Co.	580	11	250	4	1	130	250	260	1969	90
Daerim Powder Metallurgy Co.	320	11	200	2	1	130	110	230	1975	60
Seoul Sintered Metal Co.	150	7	200	2	-	40	50	60	1975	20
Orient Machinery Industry Co.	260	6	500	1	1	40	90	140	1980	50
Mando Machinery Co.	300	8	100	5	-	140	140	180	1975	30
Handok Powder Metallurgy Co.	200	4	250	1	1	-	-	30	1982	30
Others	200	10	250	1	10	50	50	60	1974	150
Total	2010	57	-	16	14	530	690	960	-	430

TABLE VI

Ferrite Magnet and Core Makers in Korea

Name of Maker	Kinds of Products	Capacity (ton/year)	Production(ton/year) 1980	1981	1982	Pro-duction start	Employees	Remark
Korea Ferrite Co.	Magnets	3600	1700	2000	2100	1976	200	
Pacific Metals Co.	Magnets	1200	-	600	1200	1981	50	Powder supplier
Samwha Electronics Co.	Cores	3000	1500	2200	3000	1969	400	
Others	Magnets or Cores	1200	400	600	800	1974	150	
Total		9000	3600	5400	7100		800	

XXIX INTERNATIONAL CONGRESS OF PHYSIOLOGICAL SCIENCES

P. F. Iampietro

INTRODUCTION

The International Union of Physiological Sciences convenes a meeting of its members every three years in one of the member countries. The Twenty-ninth Congress was held in Sydney, Australia during 28 August to 3 September 1983. In addition to the congress a number of associated (satellite) symposia were held before and after the congress in Australia and other countries in the Pacific and Asia areas. The satellite symposia allowed more intense and detailed consideration of each topic by small groups. The congress was held at New South Wales University in the Kensington section of Sydney. The university is relatively new and has an attractive campus and buildings. All aspects of the congress were extremely well-organized by the local committees. Every need of the registrants was anticipated and provided for. About 3000 scientists attended the congress from 54 countries. Four countries, Australia (620), Japan (336), United States (606) and United Kingdom (174) had the most members (50% of the total) with Canada (94), China (41), France (52), Federal Republic of Germany (88), India (40), and New Zealand (50) contributing 12%.

The scientific program of the congress was composed of 42 invited lectures, 97 symposia, and 94 poster sessions. The lectures, posters, and symposia were grouped according to various themes such as reproduction, cardiovascular physiology, respiration, etc. The major theme areas were neurosciences and excitable membranes. A great deal of attention is being devoted to these areas worldwide so the allocation of more scientific sessions to them was quite appropriate. For the most part, five different sessions were in process simultaneously so it was not possible to listen to every paper desired. Membrane and neuroscience sessions were given priority.

SCIENTIFIC PROGRAM

- Neurotransmission Receptor Mechanisms

These papers considered the activation of receptors by neurotransmitters, primarily acetylcholine. Some aspects of excitatory and inhibitory amino acid receptors were discussed. Papers by D. Colquhoun (University College, London), J. P. Chargeaux (Pasteur Institute) and W. Trautwein (University of Saarland) discussed the fast neurotransmitter acetylcholine and ion channel openings and closings. Rate constants of channel openings and closings were presented. Papers by R. McBurney *et al.* (Medical College, Newcastle) and J. Watkins (Bristol Medical School) described the modes of action of an array of amino acids.

- Ion-coupled Membrane Transport Processes

These papers considered active transport of materials dependent on coupling with ions. A paper by U. Hopfer (Case Western Reserve University) discussed the kinetics of coupled transport processes in vesicle systems. E. Wright *et al.* (University of California, Los Angeles) considered the transport of carboxylic acid in brush border vesicles of the kidney. They conclude that three Na ions bind to a carrier and increase the affinity of the carrier for succinate. Phosphate transport in the brush border membrane vesicles is mediated by sodium-phosphate transport systems according to H. Murer (University of Zurich). Ca-transport is mediated by Na/Ca exchange mechanisms

and ATP-driven Ca-transport is mediated by high affinity Ca-ATPase. K. Ullrich (Max Planck Institute) described a common anion exchange system for the transport of inorganic and organic anions in the rat proximal tubule. Na, Cl, and K are cotransported in the thick ascending limb of the Loop of Henle as described by R. Greger (Max Planck Institute).

- Ion Permeation through Excitable Membrane Channels

The mechanisms for ion movement through membranes and some of the factors which affect permeation were discussed in this session. B. Hille (University of Washington) discussed selective and nonselective channels. Nonselective channels (cholinergic motor end plates) are of large pore size and are permeable to more than 75 cations but no anions. Single channel conductances of these end plate channels do not correlate with ion diameters. Hydrophobic cations do not permeate readily and block passage of other ions. A paper by T. Begenisich (University of Rochester) discussed Na ion permeation. Sodium channels in excitable cells are protein structures which allow the passage of millions of ions per second. The sodium pore may be occupied by more than one permeant ion at a time depending on concentration of the permeant ions. Further discussion of the dynamics of ion movements in channels was presented by P. Lauger (University of Konstanz). Molecular dynamic simulation was suggested as a promising means of analysis of microscopic channel models. Selectivity properties of sodium channels depend, to a great extent, on the properties of the inner and outer acid groups which are available for protonation from external solution. The inner group is within the pore and the second group is on the surface near the external end of the pore. The inner group seems to be more influential in this respect according to A. Naumov (U.S.S.R. Academy of Sciences). P. Barry (University of New South Wales) discussed the two primary models used for prediction of permeation through channels-electrodiffusion and rate theory.

- Integrative Action of Single Neurones

Theoretical and experimental papers were presented of neuronal activity. Effects of ions were considered and application of mathematical relationships were described. K. Krujevic (McGill University) proposes that the fall in extracellular Ca concentration upon repeated firing of spinal motoneurons, although small, has a profound effect on the neurone's firing characteristics. In closely packed areas such as the hippocampal pyramidal layer, the fall in extracellular Ca can cause a depression of synaptic transmission. A mathematical relationship was proposed by W. Rall (National Institute of Health) between the geometry of dendritic trees and electrical phenomena. His conclusion is that a cable theory can explain both transient and steady state conditions of the tree. R. Llinas (New York University) presented a summary of findings of the active properties of the neuronal membrane. More than ten different voltage-dependent conductances can be described for the somatic region of CNS neurones and five can occur in the dendritic process. These ionic mechanisms are important in the generation of rhythmic firing of the neurone. Remote synapses (distant from the soma) are very efficient (as judged by ability to drive the cell) compared with synapses closer to the soma (P. Andersen, University of Oslo), except that those synapses near the tip of the dendritic tree are very ineffective. Evidence was presented that excitatory postsynaptic potentials are spread passively in dendrites. Passive membrane conductance is proven by the fact that summation of two group IA fiber excitatory postsynaptic potentials in the same motoneurone reveal linear summation or less than linear summative properties (B. Walmsley, Australian National University).

- Single Channels and Noise Analysis

Factors which affect openings and closings of channels and inhibitory synaptic effects were discussed in this session. A technique (Giga-ohm seal) for directly measuring the conductance of end-plate channels in toad muscle fibers is described. Various extracellular cations were used to alter conductance-voltage relationships (N. Quartararo, University of New South Wales). Ion channels in mammalian central neurones were studied by an improved patch-clamp technique by O. Hamill, *et al.* (Max Planck Institute). The characteristic kinetics of GABA- and glycine-receptor channels provide a molecular basis for differences in inhibitory synaptic events evident from *in situ* recordings in various regions of the central nervous system where either GABA or glycine has been identified as the likely inhibitory transmitter. Inhibitory synaptic channels in locust muscle membranes have a mean lifetime of four ms. Miniature inhibitory junctional currents have a mean amplitude of 2.6 nA at -80 MV. It is estimated that a single quantum of GABA opens about 600-1000 inhibitory channels whereas a single quantum of transmitter at the excitatory glutamate synapse opens only about 200-250 channels. This difference may reflect the low affinity of the glutamate receptor (S. Cull-Candy, University College, London). K. Magleby, *et al.* (University of Miami) presented a model which can account for the open and shut interval distributions of Ca-activated K channels in cultured rat muscle. The model also accounts for long open distributions by assuming that binding of an additional Ca ion (compound state) prevents the channel from closing.

- New Gated Channels

New channels are described in several types of tissues, including rods and cones, nerve cells, cardiac tissue and others. Isolated rods and cones were voltage clamped and gated currents studied. The gated currents were activated by hyperpolarization of the membrane. Both cell types have gated currents but the properties of the currents differ although they behave according to the Hodgkin-Huxley models. The authors, D. Attwell, *et al.* (University College, London) state that the rod's photocurrent is larger than the cone's and therefore has a greater influence on the rod's light responses than the photocurrent in the cone. P. Adams, *et al.* (State University of New York at Stony Brook) describe a new time- and voltage-dependent potassium current which they call the Mcurrent, I_m. It is present in amphibian and mammalian nerve cells. They state that I_m is the only noninactivating current operating between resting potential and spike threshold and therefore can decisively influence cell firing. An extremely slow inward current has been described (K. Lee, *et al.*, University of Oxford) in cardiac ventricular cells. It is 2 nA in amplitude and the time course of activation and inactivation is 300 ms at room temperature. In the absence of this inward current, the cell does not contract even with strong depolarization. Candidates for the mechanism are Ca-activated Na/K current or Ca-activated Na-Ca electrogenic exchange.

SATELLITE SYMPOSIUM

- Membrane Permeability: Experiments and Models

This one and a half-day symposium was held at the South Australia Institute of Technology, Adelaide, Australia on 25-26 August 1983. Sixteen papers were presented and eight posters were displayed. A few of the papers will be described briefly here.

C. Slayman, *et al.* described a kinetic model of electrophoretic cotransport which, when certain restrictions are lifted, can accommodate nearly all kinetic observations

reported from cotransport experiments. The authors consider binding to be nonrandom thereby allowing sequential treatment of equations. There is no imposition of equilibrium binding. I. Tasaki measured the water content of membranes (mechanical measure of swelling or increase in volume) during depolarization of squid axon. Swelling of the axon and an increase in intracellular pressure was related to a contraction of the axon and the peak of the swelling coincided with the peak of membrane conductance. The swelling is related to ion exchanges. When the membrane is hyperpolarized there is a shrinkage of the axon. Tasaki states that all excitable systems (rods, cones, muscle, etc.) show the swelling phenomena and it appears to play an important role in the physiology of the vertebrate nervous system. Work by F. Smith on the alga *Chara corollina* indicates that the mechanism for the uptake of amine cations is independent of that for uptake of K. These results were obtained by providing conditions which would alter uptake of methyl ammonium and potassium inversely if the same channels transported ammonium and K. The effects of intracellular divalent cations on Na and K permeabilities in squid giant axons was studied by S. Yamagishi *et al*. Cr, Ca, Mg, Mn, and Co suppressed both the inward current (Na) by 5-40% and outward current (K) by 10% while other cations (Be, La, Cd) suppressed neither current. K. Nishi determined that calcium antagonists, beta blockers, local anesthetics, barbiturates, and n-alcohols, perfused internally in the snail neurone, depressed the peak amplitude of the calcium currents in a dose dependent manner. When slow muscle fibers are denervated, the membrane synthesizes Na channels and after a time the fibers acquire spike potentials when stimulated whereas they did not spike when the nerve was intact and stimulated. AMP and norepinephrine (which enhances $_{c}$AMP activity) increased the formation of Na channels. The authors (H. Schmidt, *et al.*) suggest that $_{c}$AMP regulates the incorporation of Na channels into the membrane of slow muscle fibers. Nucleated red blood cells (frog) were studied by O. Hamill by the extracellular patch clamp technique in order to describe the characteristics of the Ca-sensitive K channel. When external Na was replaced by K inward currents of 0.8 pA were recorded (outward currents of 2 pA occurred when Na was present). Substitution of internal K by Na reduced channel permeability and increasing internal Ca increased the probability of channel opening.

CONCLUSION

In summary, the congress scientific content was of an exceptionally uniform and high quality. The large number of presentations in the neuroscience and membrane phenomena sessions was appropriate considering the international interest in these areas. The rapid advances being made are, in part, a result of the use of relatively new and sophisticated techniques and equipment.

III-V COMPOUND SEMICONDUCTOR RESEARCH AT THE OPTOELECTRONICS JOINT RESEARCH LABORATORY

Yoon Soo Park

INTRODUCTION

The Optoelectronics Joint Research laboratory was established 1 October 1981 as a part of a national research and development project, Optical Measurement and Control Systems, in a joint effort of the Ministry of International Trade and Industry (MITI) and nine members of various industrial corporations. The objective of the laboratory was to establish optoelectronic integrated circuits (OEIC) technology which is considered to play a key role in advanced systems for optical fiber communication, information processing, and sensing.

The laboratory is located in the city of Kawasaki, outside Tokyo. The laboratory houses approximately 50 scientists pooled from participating members of industrial corporations (approximately six scientists from each company) and includes 10 members of the support staff. They are involved in research to identify and resolve fundamental problems affecting the development of future OEIC technology. To undertake such basic problems, they are concentrating on the following three major research areas:

- bulk crystal growth technology for high quality GaAs (or InP) crystals which are suitable for OEIC,
- new epitaxial crystal growth technologies as well as new ion beam process technologies for fabricating OEIC devices, and
- advanced techniques for materials characterization.

The laboratory has one of the most unique facilities in that a complete array of characterization and analytical techniques exist in one place. For 50 scientists, there is an abundance of premium equipment arranged in spacious surroundings. A number of characterization and analytical techniques available at the laboratory includes photoluminescence (PL), DLTS, Hall, C-V, SIMS, XPS, Raman, TEM, SEM and Rutherford backscattering. In addition, there are materials growth facilities including the high pressure LEC pullers for bulk GaAs and InP crystal growth, three MBE reactors, and a low energy micro-ion beam system for maskless ion beam doping.

In the research areas specified above, research programs are being performed by six research groups:

Bulk Crystal Growth Technology Group
Head: Dr. T. Fukuda
Maskless Ion Beam Doping Technology Group
Head: H. Hashimoto
Multilayer Epitaxial Crystal Growth Technology Group
Head: M. Ishii
Interface Technology Group
Head: H. Nakashima
Compound Semiconductor Fabrication Technology Group
Head: T. Iizuka
Advanced Crystal Characterization Technology Group
Head: T. Iizuka

RESEARCH ACTIVITIES

- Bulk Crystal Growth Technology

Concentrated efforts are being made in developing bulk crystal growth technology for GaAs and InP crystals of high purity and high quality using the LEC growth technique. In order to produce large diameter (2-4 inches) undoped, semi-insulating GaAs single crystals with low dislocation density, low residual impurity, and no thermal conversion for use in the fabrication of GaAs integrated circuits (ICs) and optoelectronic devices, many new growth techniques are employed. By applying computer automated diameter control (CADC), a new *in situ* melt purification process, and a thermal reflector, large, homogeneous crystals with low dislocation density are reproducibly yielded.

In the CADC technique, several important parameters measured during growth are fed into the computer and processed in real time in order to overcome the instability characteristics of the GaAs melt.

The crystal diameter is computer-controlled by a precise buoyancy correction weight signal and the compensation of a large time lag. As a result, large <100> oriented GaAs single crystals of 2-4 inches in diameter regulated within $\pm$ 1.5% are successfully grown in the lower temperature gradient of 50°C/cm.

The laboratory is using the new *in situ* melt purification technique to reduce the background concentration of Si in undoped GaAs. In the new technique, the melt is purified by *in situ* distillation. The *in situ* distillation process involves the abrupt reduction of the high Ar pressure inside the growth chamber to near atmospheric pressure causing bubbling in the molten B_2O_3. During the bubble evaporation, which is mainly of gaseous water vapor, some impurities such as Si evaporate from the melt in the form of gaseous SiO_2. In addition, the electrical conductivity of the GaAs melt is being monitored by applying alternating electric current (15 volts and 50 Hz). It is found that there is a strong correlation between the melt conductivity, the degree of melt purification, and the resultant resistivity of the crystal. For example, to obtain undoped semiconducting crystals, the current in the melt should be less than 0.5 mA with pressure of 20 atm prior to the pulling initiation. In this way, undoped semiconducting crystals with a low Si concentration (5×10^{14} cm^{-3}) are reproducibly grown using either PBN or SiO_2 crucibles.

To reduce the dislocation density, the low pressure (3-8 atm) and low temperature gradient (50°C/cm) approach is being employed. The low temperature gradient is attained by lowering the location of the crucible and by means of a thermal reflector placed above the crucible. Under the low pressure gradient, the temperature gradient is drastically reduced to 50°C/cm. The crystals grown under low pressure and low temperature gradients show a low dislocation density of 8×10^3 to 1×10^4 cm^{-2} characterized by U-shape distributions. This contrasts with crystals grown in high pressure (40 atm) and high temperature gradients ($\geq$100°C/cm) which show a high dislocation density of ~1×10^5 cm^{-2} characterized by W-shape distributions.

Highly homogeneous undoped semi-insulating crystals are produced with the melt composition of As/GaAs = 0.499-0.501 by minimizing As evaporation using low water content B_2O_3 ($\leq$100 ppm) covering the GaAs melt during the heating process.

The laboratory is conducting extensive research on magnetic field assisted crystal growth of GaAs. They have developed a new magnetic field LEC (MLEC) pulling

apparatus using two superconducting magnets. The superconducting magnets were designed to deliver up to 3000 G transversely to the center of the chamber. The application of the magnetic field to the melt during the growth of silicon has been known to improve the crystal quality through controlled oxygen concentration. However, there has been no report on the effect of the magnetic field on the growth of GaAs single crystals.

They have successfully grown, for the first time, undoped, <100> oriented, 2-inch diameter GaAs single crystals in the presence of a 1300 G magnetic field with 20 atm pressure of argon using the direct synthesis technique with either a PBN or SiO_2 crucibles. A crystal was pulled at the rate of 9 mm/h and rotated at 0-10 rpm. The crystals grown in the presence of the magnetic field were striation-free and had low dislocation density (3000-8000 cm^{-2}). However, an undoped, semi-insulating crystal obtained from a PBN crucible exhibited n-type conductivity as the magnetic field was applied during the growth period. The resistivity of the crystal was about 10 Ω-cm at 1300 G.

When the crystals grown in the magnetic field were examined by photoluminescence (PL) and DLTS methods, the concentration of EL2 was reduced considerably indicating that the decrease in resistivity must be due to the decrease in deep-level concentrations.

As the pulling speed of the crystal was increased in the magnetic field from 9 mm/h, the resistivity of the crystal was changed from semiconducting (10^1 - 10^2 Ω-cm) to semi-insulating (10^8 Ω-cm) at 18 mm/h for the PBN grown crystals and at 36 mm/h for the SiO_2 grown crystals. At a low pulling speed of 9 mm/h, a minute addition of Cr ~ 0.007 wt.ppm) was needed to change the conductivity of the crystal from semiconducting to semi-insulating. The resistivity of this superlow Cr (an order of the magnitude lower than the Cr content of Cr-doped LEC crystals) exhibited remarkable uniformity from the top to the tail of the crystal ingot. In summary, through the application of a magnetic field to the growth of GaAs single crystals:

- growth striations caused by thermal convection can be eliminated,
- contamination of B and Si impurities from crucibles can be reduced,
- deep-level defect concentration can be lowered,
- fast pulling speed can be applied, and
- low dislocation density can be obtained.

The first two effects have already been demonstrated in the magnetic field assisted Czochralski (MCZ) growth of homogeneous and high purity Si crystals. The last three effects can be considered unique in the magnetic field assisted LEC (MLEC) growth of GaAs.

- Maskless Ion Beam Technology

The laboratory is conducting research and development on maskless ion implantation based on micro-ion beam technology, and has recently developed a 100 keV maskless ion implantation system with an Au-Si-Be metal ion source for III-V compound semiconductors.

Recently, great interest has been generated in maskless ion implantation by scanning submicron focused ion beams because it offers an attractive technology for fabricating semiconductor devices without photolithography. In the maskless process, the surface of semiconductor layers can be kept clean by avoiding the formation of contaminants and defects.

The 100 keV maskless ion implantation system developed by the laboratory is capable of emitting either Si^{++} (n-type dopant) or Be^{++} (P-type dopant) ion beams of 0.1 μm spot diameters at the target currents of 20 and 10 pA, respectively. In appearance it resembles the modified Jeol transmission electron microscopy.

Using this system, they have implanted submicron Si and Be ion beams into MBE grown epitaxial GaAs layers with doses of 10^{12} to 10^{15} cm^{-2} at 160 keV and evaluated lateral spreads of impurities, before and after annealing. It has been observed that, for high dose implantion ($\sim 5 \times 10^{14}$ cm^{-2}), there is a lateral spread of 1 μm or more for the focused ion beam of a 0.1 mm spot diameter. For doping of submicron width, low doses ($\leq 10^{13}$ cm^{-2}) and low energy implantation is recommended.

In addition, they have evaluated GaAs layers grown by molecular beam epitaxy (MBE) at 600°C on the selectively buried Be-doped layers by maskless ion implantation with a focused ion beam. Low temperature (4.2°K) photoluminescence data on the MBE layers has indicated that a high quality GaAs could be grown on top of the implanted layers by MBE at 600°C without postimplantation anneal.

There is a concerted effort in combining maskless ion implantation technology with MBEW technology for growth of a multilayer structure of III-V compound semiconductors. The laboratory is preparing to combine the Maskless Ion Implantation System and the Molecular Beam Epitaxy Reactor in a single system. The combination of these two technologies are being studied from both practical and fundamental viewpoints.

- Multilayer Epitaxial Crystal Growth Technology

The laboratory has three MBE reactors (one Varian and two Riber) dedicated to multilayer structure studies of III-V compound semiconductors. Their aim is to fabricate the integrated semiconductor lasers for future optoelectronic integrated circuits (OEIC).

Recently they have fabricated GaAlAs multiquantum well (MQW) buried heterostructure (BH) lasers using diffusion-induced disordering (DID). The layers grown by MBE on p-type (100) GaAs consist of a 3 μm $Ga_{0.65}Al_{0.35}As$ (Be: 1.3×10^{18} cm^{-3}) cladding layer, a 1 μm $Ga_{0.7}Al_{0.3}As$ (Be: 1.3×10^{18} cm^{-3}) optical guide layer, an undoped MQW active layer consisting of 10 periods of GaAs quantum well (80 Å) and $Ga_{0.7}Al_{0.3}As$ (60 Å), a 1 μm $Ga_{0.65}Al_{0.35}As$ (Si: 1.2×10^{18} cm^{-3}) cladding layer and 0.5 μm GaAs (Si: 2×10^{18} cm^{-3}) cap layer. By dry etching, the n-GaAs cap was removed leaving a 4 μm wide stripe region using a Si_3N_4 mask. Zinc diffusion was then performed in an evacuated silica ampule at 660°C for 48 minutes using $ZnAs_2$. As a result, the MQW structure became compositionally disordered. In order to electrically isolate the n-GaAs and Zn diffused $Ga_{0.65}Al_{0.35}As$ cladding layer, zinc diffused regions of the cap layer were selectively etched by a perioxide/alkaline solution. The top p-GaAlAs surface was anodically oxidized in oxygen plasma and a ohmic contact to the n-type layer was formed.

A MQW BH laser with 300 μm cavity length had a threshold current I_{th} of about 50 mA. By optimization of the MQW structure and refinement of the fabrication process, lower threshold current is expected.

- Materials Characterization Activity

Thorough and comprehensive material characterization is strongly emphasized for establishing the technology basis of future OEICs. Tests for detection of impurities, defects, and stoichiometric measurements in bulk crystals are extensively performed. Results of materials characterization is closely correlated with the bulk crystal growth process and other device fabrication processes.

A number of characterization techniques are being employed to evaluate the material. For example, the carrier concentrations in the epitaxial layers of nAl_xGa_{1-x}, As are determined from Raman scattering by the coupled plasmon-LO phonon modes. In addition, the alloy composition is also deduced by measuring the frequencies of GaAs-like and AlAs-like LO phonons from the surface depletion layer.

The influence of growth conditions and alloy composition on deep electron traps for MBE-grown n-AlGaAs is being studied using DLTS methods. It has been found that the thermal activation energy of deep electron traps varied with alloy composition and that the concentrations of the electron traps decreased while increasing growth temperature or decreasing the group V/III beam flux ratio. The effect of the beam flux ratio is found to be less than that of the growth temperature.

Extensive research on the identification of defects and residual impurities in undoped LEC semi-insulating GaAs is underway in this laboratory. Recently, they have been examining the behavior of the two 4.2°K PL peaks at 0.65 eV and 0.8 eV appearing in undoped LEC SI-GaAs under different growth conditions.

The 0.65 eV band appeared predominantly in the SI crystals grown from a SiO or from a crucible using B 0 encapsulant containing high water content. On the other hand, the 0.8 eV band was dominantly observed in crystals grown from a PBN crucible with dry ($\leq$ 100 ppm H_20) B_2O_3 encapsulant.

On the basis of careful investigations and correlation of the PL intensity, etch pit density (EPD), and resistivity distributions along the growth direction and along the wafer diameter, they have established that the 0.65 eV and 0.8 eV bands have different origins. Undoped LEC SI GaAs crystals were classified into two groups on the basis of appearance of these two deep level bands.

As the 0.8 eV PL band increased in its intensity under As-rich conditions, they have concluded that it was associated with native point defects related to excess As such as an As_{Ga} antisite defect. It has been conjectured that the origin of the 0.65 band was due to a complexity involving oxygen and silicon.

SUMMARY

The Optoelectronics Joint Research Laboratory is well-equipped and has a well-coordinated program in materials growth, characterization, and device fabrication. The scientific staff is making great strides in their work and are highly motivated. They truly believe that the success of future OEIC technologies are dependent on the advancement of basic materials technology. With this conviction, they are working towards the common goal of obtaining a "breakthrough" in OEIC technologies. Their motto is, "True research has just begun."

The laboratory is operated under the leadership of Dr. K. Sakurai, the Director, and Dr. Izuo Hayashi, Technical Director.

For further information, address mail to:

Optoelectronic Joint Research Laboratory
1333, Kami-Odanaka, Nakahara-ku
Kawasaki-shi
Kanagawa-ken 211, Japan

THE FIFTH INTERNATIONAL CONGRESS OF IMMUNOLOGY AND A REPORT ON A SATELLITE SYMPOSIUM

Jeannine A. Majde

INTRODUCTION

In August 1983, I visited Japan for the purpose of attending the Fifth International Congress of Immunology in Kyoto (21-27 August 1983), and a satellite symposium entitled "Immunomodulation by Chemically Defined Adjuvants" in Sapporo (29 August-1 September 1983). In between the two meetings, I visited the Oriental Medicine Institute at the University of Toyama (28-29 August 1983) to investigate the research activities there in Chinese herbal medicine. [This *Bulletin*, *9* (1), 160 (1983)]

The International Congress of Immunology is a triennial event having previously been held in Washington, D.C.; Brighton, England; Sydney, Australia; and Paris, France. The next congress will be held in Toronto, Canada, in 1986. The fifth congress attracted about 4000 participants, about half of whom were Japanese scientists. U.S. representation appeared to trail European representation as indicated by the number of European speakers in symposia and workshops.

- Technical Program

The format of the congress consisted of 16 formal symposia on a wide range of topics and 68 workshops that combined posters with three-minute slide presentations. Biomedical sciences meetings have been exploring a number of formats lately to accommodate the large numbers of presentations. I felt that this one was quite successful as a means of communicating both established themes (the formal symposia) as well as emerging areas (the workshops). The combined poster and brief presentation, when properly presented and moderated, got the important points across and permitted adequate discussion by interested parties at the poster site. In this case, the posters were up for one hour preceding the presentations; an even more useful format might result if posters were manned a half-hour after the presentation as well.

The subject matter of the congress covered all aspects of immunology from the processes involved in inflammation in such diseases as asthma and rheumatoid arthritis to the molecular aspects of lymphocyte interactions that form the focus of most of basic research in immunology today. Of special interest to me were the workshops on thymic hormones, immunomodulating drugs, and neuroendocrine mechanisms regulating the immune system. These are new areas of immunology that represent a broader look at endogenous regulatory mechanisms than simply the cell-cell interactions within the immune system itself.

THE SATELLITE SYMPOSIUM

One aspect of immunomodulating drugs was the focus of the satellite symposium entitled "Immunomodulation by Chemically Defined Adjuvants" held in Sapporo. This meeting emphasized the potentiation of the immune response by synthetic adjuvants under development in Europe and Japan. These drugs have been explored heavily as immunotherapy in cancer patients. Cancer depresses the immune function in some way that compromises the general health of the individual as well as his/her ability to destroy metastatic tumor cells. Current cytotoxic therapy directly suppresses the

immune response and aggravates the immunosuppression induced by the cancer. The primary goal of modern cancer immunotherapy is to restore normal levels of immune competence and to stimulate the patient's immune system to assist in destroying tumor cells that escape surgery or other therapies. Other targets of immunotherapy are stimulating the immune response to vaccines (the conventional immunological adjuvant) and to pathogenic microorganisms. These two areas are of primary interest in that

- a clinically safe, efficacious adjuvant for important vaccines does not currently exist (necessitating use of large quantities of expensive vaccines and booster inoculations), and

- immunotherapy has the potential for serving as broad spectrum treatment for intracellular microorganisms, such as viruses, for which no treatment now exists.

As with cancer, immunotherapy can logically be employed to act synergistically with antibiotics or other chemotherapeutics, where they exist, to speed recovery from an infectious disease.

The satellite symposium in Sapporo focused on the cancer aspects and some work on anti-inflammatory action of some new drugs. The prototype of the synthetic adjuvants is a molecule called muramyl dipetide or MDP. This molecule consists of a sugar linked to two amino acids, one D and one L. This molecule is the smallest active immunostimulatory component of tuberculosis bacteria cell walls, famous for their immune activity. MDP itself induces sleep, causes fever, and promotes autoallergic conditions, but a new butyl derivative called murambutide (developed at the Institute Pasteur in Paris), appears to retain the positive but not the negative features of the molecule. Yet another derivative first reported at the Sapporo meeting is MTP-PE, a muramyl tripeptide-lipid developed by CIBA-GEIGY, Basel, Switzerland. This molecule has profound antiviral activity in animals when one small dose is administered locally (the repiratory or genital tracts) up to two weeks prior to infection or up to one week following infection.

At the Sapporo symposium, I was invited to chair a session and to present a paper on my work with the immunomodulator Therafection, done in collaboration with Dr. Paul Gordon of the Loyola Medical School in Chicago. The paper was entitled "Regulation of Immunological Inflammation by Therafection and Other Immunomodulators" in which chronic inflammatory lesions induced by bacteria were suppressed by relatively large doses of several drugs. Several of the drugs compared will induce resistance to viruses and fungi when given in small doses in a particular regimen. An interesting feature of these drugs is that they appear to be activated by environmental or emotional stress by mechanisms not currently defined and may generate protection against infections by preventing infection-induced (or stress-induced) immunosuppression. These drugs, many of which are nontoxic and orally active, offer a novel alternative to conventional antibiotic therapy for infectious diseases and are being actively developed in Japan, France, and Belgium.

ORIENTAL MEDICINE RESEARCH IN JAPAN

Jeannine A. Majde

While in Japan for the Fifth International Congress of Immunology, held 21-27 August 1983 in Kyoto, Dr. Arthur G. Johnson of the University of Minnesota School of Medicine-Duluth and the author visited the Research Institute for Oriental Medicine (Waken Yaku) at the Toyama Medical and Pharmaceutical University, Toyama City, Japan. We were graciously hosted by Professor Zenichi Ogita and other members of the Department of Biochemical Pathology.

Professor Ogita was originally trained in human genetics and is active in that field in Toyama as well as at Yale University and the University of Michigan. His work currently includes development of techniques for separating human chromosomes with a fluorescent cell sorter. However, as a consequence of his personal experience with back pain treated first by conventional Western techniques (unsuccessfully) and then by oriental herbal therapy (successfully), his interests turned to investigating the chemical basis for herbal medicines in use in China, Korea, and Japan for millenia. His Department of Pathogenic Biochemistry, together with the Departments of Organic Chemistry, Natural Drug Resources, Pharmacometrics and Clinical Utilization make up the Research Institute for Oriental Medicine in Toyama. The addition of three more departments is planned. The basic research of the institute is closely coordinated with chemical studies at the adjoining hospital which provides both Western and oriental medical treatment.

The institute currently has about 100 herbs under study and plans to examine over 3000 in time. About 180 herbs are used clinically at present. The analysis of their action is complicated by the fact that prescriptions (over 2250 formulations in use) nearly always contain multiple crude herbal extracts (boiled in tea kettles fresh each day) and are traditionally finely tuned not only to the disease under treatment but to the physiology of the individual patient. Professor Ogita is trying to bring some order out of this chaos by computerizing formulations and their use in different disease states.

The herb most extensively studied at the institute (and elsewhere) is the ginseng root. Professor Hikokichi Oura of the Department of Biochemistry is focusing on ginseng chemistry and recently published the first issue of a journal entitled, *The Ginseng Review* (in Japanese). From an immunological perspective ginseng is of interest because it contains a variety of saponins, a group of chemicals active as immunological adjuvants. We did not determine whether ginseng has been studied for its immunologic effects as was done with a polysaccharide extracted from the fungus *Ganoderma applanatum* by Dr. Nakashima in the Department of Biochemistry. Dr. Nakashima showed an enhancing effect of the polysaccharide on delayed hypersensitivity to protein antigens in mice and plans to use this model for further immunological analyses of oriental herbs.

Another compound under study is glycyrrhetic acid, extracted from licorice. The pharmacokinetics of this compound are being studied in normal and ill individuals using a radioimmunoassay developed by Dr. Yano in the Department of Internal Medicine.

Our brief visit permitted only a hasty look at this highly complex field of research. The institute clearly faces a formidable task in trying to systematically unravel this ancient folk medicine. However, the potential value of this approach is obvious when we look at some of the drugs in use in Western medicine (aspirin, digitalis)

derived from similar sources. The close ties of the institute and the Japanese pharmaceutical industry should bring their work to clinical application in the near future.

INTERNATIONAL MEETINGS AND EXHIBITIONS IN THE FAR EAST

1984-1986

Compiled by Seikoh Sakiyama

The Australian Academy of Science, the Japan Convention Bureau, and the Science Council of Japan are the primary sources for this list. Readers are asked to notify us of any upcoming international meetings and exhibitions in the Far East which have not yet been included in this report.

1984

Date	Title	Site	For Information, contact
April 3-5	International Teleconference Symposium	Tokyo, Japan	Data Communications Department Kokusai Denshin Denwa Company, Ltd. 2-3-2, Nishi-Shinjuku Shinjuku-ku, Tokyo 160
April 3-6	Communications Tokyo '84 (Exhibition)	Tokyo, Japan	Communication Industries Association of Japan Sankei Building Annex, 8F 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
April 10-13	Softopia '84 Tokyo (Computer Software)	Tokyo, Japan	Softopia '84 Tokyo Secretariat SK Building 1-22-9 Ginza Chuo-ku, Tokyo 104
April 20-21	OA Show [Office Automation (OA)]	Osaka, Japan	Nihon Keizai Shimbun Company, Ltd. 1-1, Maenocho, Kyobashi Higashi-ku, Osaka 540
April 24-27	Computer Graphics Tokyo '84 (International Conference and Exhibition)	Tokyo, Japan	Japan Management Association 3-1-22 Shiba-Koen Minato-ku, Tokyo 105
April (tentative)	Geology, Mineral and Energy Resources of Southeast Asia (GEOSEAV)	Kuala Lumpur, Malaysia	Dr. T.T. Khoo Department of Geology University of Malay Kuala Lumpur 22-11
May 9-13	'84 Tokyo International Metalworking Machines Exhibition	Tokyo, Japan	The Industrial Daily News 1-8-10, Kudan-Kita Chiyoda-ku, Tokyo 102

Date	Title	Site	For information, contact
	'84 Tokyo Metalforming Machines Exhibition		
	'84 Yamagata Machinery Industry Exhibition		
	'84 Industrial Robots Exhibition		
May 15-18	The 11th Modern Scientific Instruments Exhibition	Nagoya, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
May 21-25	The 4th Australian and New Zealand Conference on Geomechanics	Perth, Australia	Dr. J. Sullivan Science House 712 Murray Street Perth, W.A. 6000
May 29-June 1	The 5th International Executive Meeting of Large Dams	Tokyo, Japan	Japan Large Dam Committee 1-4-1-2, Uchisawai-cho Building Uchisaiwai-cho, Chiyoda-ku, Tokyo 150
May 25-27	The 14th Hamamatsu Environment Preserving Machinery and Equipment Exhibition	Hamamatsu, Japan	The Nihon Kogyo Shimbun Company, Ltd. 2-4-9, Umeda Kita-ku, Osaka 530
May (tentative)	The 5th International Soils Expansion Conference	Adelaide, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
May (tentative)	The 21st All Japan Optical Measuring Instruments Fair	Tokyo, Japan	Japan Optical Measuring Instruments Manufacturers Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
May (tentative)	Microcomputer Show'84	Tokyo, Japan	Japan Electronic Industry Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba Koen Minato-ku, Tokyos 105

Date	Title	Site	For information, contact
June 7-11	LASER '84 Osaka Exhibition	Osaka Japan	Exhibition Office Osaka Branch Nikkan Kogyo Shimbun 2-1, Kyobashi-maeno-cho Higashi-ku, Osaka 540
June 7-11	Intermex '84 Exhibition	Osaka, Japan	Exhibition Office Osaka Branch Nikkan Kogyo Shimbun 2-1, Kyobashi-maeno-cho Higashi-ku, Osaka 540
June 7-11	Robotics '84 Exhibition	Osaka, Japan	Exhibition Office Osaka Branch Nikkan Kogyo Shimbun 2-1, Kyobashi-maeno-cho Higashi-ku, Osaka 540
June 11-13	The 4th Congress on World Computing Services Industry	Tokyo, Japan	Japan Software Industry Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
June 11-14	'84 CAD/CAM System Show	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
June 13-16	The 14th JPCA Show '84 [Japan Printed Circuit Association (JPCA)]	Tokyo, Japan	Japan Printed Circuit Association Kamiyacho Building, 6F 5-12-12, Toranomon Minato-ku, Tokyo 105
June (Tentative)	'84 Tokyo International Antipollution Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
June (tentative)	New Matex '84 (New Materials and Related Equipment and Systems) Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
July 2-5	The 4th Office Automation Show	Tokyo, Japan	'84 OA Show Office Nihon Keizai Shimbun 1-9-5, Ohtemachi Chiyoda-ku, Tokyo 100

Date	Title	Site	For information, contact
July 11-14	The 4th International Drying Symposium	Kyoto, Japan	Dr. Ryozo Toei The Society of Chemical Engineers, Japan 4-6-19, Kobinata Bunkyo-ku, Tokyo 112
July 22-August 1	International Symposium on Marine Plankton	Shimizu, Japan	Mr. T. Kubota Marine Biological Center Tokyo University 1000, Orito, Shimizu Shizuoka 424
July 25-27	Hi-Tech '84 Osaka (Exhibition)	Osaka, Japan	Secretariat, Hi-Tech '83 c/o Marcom International, Inc. Akasaka-Omotemachi Building, Rm 705 4-8-19, Akasaka Minato-ku, Tokyo 107 (Application necessary)
July 25-28	The 10th International Symposium on Nonlinear Acoustics	Kobe, Japan	Dr. Akira Nakamura, Chairman, The Institute of Scientific and Industrial Research Osaka University 8-1, Mihogaoka, Ibaraki Osaka 567
July 26-30	The 10th International Congress of Biometeorology	Tokyo, Japan	Dr. Hiroshi Inaba Juntendo Medical School 2-1-1 Hongo Bunkyo-ku, Tokyo 113
July (tentative)	'84 Microcomputer Show	Osaka, Japan	Japan Electronic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
July (tentative)	The 12th Conference International Cartographic Association	Perth, Australia	Mr. D. T. Pearce P.O. Box 6208 Hay Street East Perth, W.A. 6000

1984 Continued

Date	Title	Site	For information, contact
August 19-24	The 13th Congress of the International Commission for Optics	Sapporo, Japan	Professor S. Fujiwara Secretary of the ICO-13, Sapporo c/o Simul International Inc., Kowa Building 1-8-10, Akasaka Minato-ku, Tokyo 107
August 22-29	Australian Academy of Science The 5th International Congress on Mathematical Education	Adelaide, Australia	Dr. J. Gaffney Wattle Park Teachers Ct. Kensington Road Wattle Park, S.A. 5066
August 24-30	The 5th International Congress on Mathematical Education	Adelaide, Australia	Dr. John Mack Department of Mathematics University of Sydney N.S.W. 2006
August 26-31	The 3rd International Congress on Cell Biology	Kyoto or Kobe, Japan	Japan Society for Cell Biology Shigei Medical Research Institute 2117 Yamada Okayama 701-02
August 26-September 1	International Conference on the Photochemical Conversion and Storage of Solar Energy	Osaka, Japan	The Society of Kinki Chemical Industry 1-8-4, Utsubo-hommachi Nishi-ku, Osaka 550
August 27-31	Shiga Conference '84 on Conservation Management of World Lake Environment	Otsu, Japan	Department of Civil Life and Environment Shiga Prefectural Government 4-1-1, Kyomachi, Otsu Shiga 550
August 27-September 1	The 9th International Conference on Raman Spectroscopy	Tokyo, Japan	Professor M. Tasumi Department of Chemistry Faculty of Science University of Tokyo 7-3-1, Hongo Bunkyo-ku, Tokyo 113

Date	Title	Site	For information, contact
August (tentative)	'84 Home Mechatronics Show	Osaka, Japan	'84 Home Mechatronics Show Office Nihon Keizai Shimbun Company, Ltd. 1-1, Maenocho, Kyobashi Higashi-ku, Osaka 5140
August (tentative)	International Micrographic Conference	Singapore	Dr. Teo Seng-kwee Singapore Micrographic Society 17-18 Lewin Terrace Singapore 0617
September 1-7	The 6th International Congress of Virology	Sendai, Japan	Professor T. Ebina Department of Bacteriology, Medical School Tohoku University 2-1, Seiryo-cho Sendai, Miyagi 980
September 2-6	International Symposium on Growth and Differentiation of Cells in Defined Environment	Fukuoka, Japan	ISGDCDE Secretariat Japan Convention Service, Inc. Nippon Press Center Building 2-1, 2-chome, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
September 2-7	International Symposium on Snow and Ice Processes at the Earth's Surface	Sapporo, Japan	The Institute of Low Temperature Science Hokkaido University 8-chome, Kita 19-Jyo Kita-ku, Sapporo 060
September 2-8	The XIIth International Biometric Conference	Tokyo, Japan	Dr. T. Okuno Department of Mathematical Engineering and Instrumentation Physics Faculty of Engineering Tokyo University 7-3-1, Hongo Bunkyo-ku, Tokyo 113
September 3-7	The 1st International Conference on Technology of Plasticity	Tokyo, Japan	Japan Society for Technology Plasticity Torikatsu Building, 3F 5-2-5, Roppongi Minato-ku, Tokyo 106

1984 Continued

Date	Title	Site	For information, contact
September 3-7	The 9th International Symposium on Neurosecretion	Fuji, Japan	Professor S. Ishii Department of Biology School of Education Waseda University Nishi-Waseda Shinjuku-ku, Tokyo 160
September 10-15	The VII International Symposium on Organo-silicon Chemistry	Kyoto, Japan	Dr. Makoto Kumata Faculty of Engineering Kyoto University Yoshida-Honcho Sakyo-ku, Kyoto 606
September 11-14	The 10th International Conference of IMEKO TC-3 on Measurement of Force and Mass (International Measurement Confederation)	Kobe, Japan	Professor T. Ono Department of Mechanical Engineering College of Technology University of Osaka 4-804, Ume-machi, Mozu Sakai, Osaka 591
September 19-22	IATSS Symposium on Traffic Science 1984	Tokyo, Japan	Internatioal Association of Traffic and Safety Sciences 2-6-20, Yaesu Chuo-ku, Tokyo 104
September 25-29	'84 Tokyo Industrial and Engineering Exhibition '84 Tokyo Engineering Design Efficiency Exhibition '84 Tokyo Automatic Control and Instrumentation Exhibition '84 Tokyo Automatic and Labor-saving Machines Exhibition '84 Computer Graphic System Show	Tokyo, Japan	The Industrial Daily News 1-8-10, Kudan-Kita Chiyoda-ku, Tokyo 102
September (tentative)	'84 Fluid Power International Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100

1984 Continued

Date	Title	Site	For information, contact
October 1-6	The 3rd Asian Pacific Regional Astronomy Meeting of IAU	Tokyo, Japan	Professor T. Kogure Department of Astronomy Faculty of Science University of Kyoto Sakyo-ku, Kyoto 606
October 1-7	Pacific Region Wood Anatomy Conference	Tsukuba, Japan	P.O. Box 16 Tsukuba Agricultural and Forestry Research Institutes Ibaraki 305
October 3-6	The 11th Measuring Instruments Exhibition	Tokyo, Japan	Japan Measuring Instruments Federation 25-1, Nandocho Shinjuku-ku, Tokyo 162
October 4-9	'84 Japan Electronics Show	Tokyo, Japan	Japan Electronics Show Association c/o Tokyo Chamber of Commerce and Industry 3-2-2, Marunouchi Chiyoda-ku, Tokyo 100
October 7-12	The XVIIth International Congress of Internal Medicine	Kyoto, Japan	The Japan Society of Internal Medicine Hongo Daiichi Building, 8F 3-34-3, Hongo Bunkyo-ku, Tokyo 113
October 15-19	Powder Industry '84 Exhibition	Tokyo, Japan	Powder Industry Office Nihon Noritsu Kyokai 3-1-22, Shibakoen Minato-ku, Tokyo 105
October 16-18	1984 International Symposium on Electromagnetic Compatibility (EMC)	Tokyo, Japan	Professor T. Takagi Department of Electrical Communications Faculty of Engineering Tohoku University Sendai, Miyagi 980
October 17-18	NRDO Conference 1984 (National Research Development Organization)	Kyoto, Japan	New Technology Development Organization 2-5-2, Nagata-cho Chiyoda-ku, Tokyo 100

Date	Title	Site	For information, contact
October 22-26	The 9th International Conference on Infrared and Millmeter Waves	Takarazuka, Japan	Dr. H. Yoshinaga Department of Applied Physics Osaka University Yamadaoka, Suita Osaka 565
October 30 November 2	The 7th International Conference on Computer Communication (ICCC '84)	Sydney, Australia	Dr. R. Cook Overseas Telecommunications 32-36 Marine Place Sydney, N.S.W. 2000
Octobver 30-November 3	International Council for Computer Communication Convention	Sydney, Australia	Dr. R. Cook Overseas Telecommunications 32-36 Marine Place Sydney, N.S.W. 2000
October 30-November 8	The 12th Japan International Machine Tool Fair	Tokyo, Japan	Osaka International Trade Fair Commission c/o International Hotel 58, Hashizume-cho-Uchi-Hommachi Higashi-ku, Osaka 540
October (tentative)	The 12th NECA Technical Fair	Tokyo, Japan	Nihon Electric Control Equipment Industry Association Daimon Hikari Building 2-1-18, Hamamatsucho Minato-ku, Tokyo 150
October (tentative)	Software Show '84	Tokyo, Japan	Japan Software Industry Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105
October (tentative)	1984 Japan Machinery Fair	Nagoya, Japan	Nagoya-shi Mihon-ichi Kyokai 2-6-3, Fukiage Chikusaku, Nagoya 464
October (tentative)	Data Show '84	Tokyo, Japan	Japan Electronic Industry Development Association Kikai Shinko Kaikan 3-5-8, Shiba-Koen Minato-ku, Tokyo 105

Date	Title	Site	For information, contact
October (tentative)	'84 Vaccum General Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
October (tentative)	'84 Osaka International Environment Preserving Machinery and Equipment Exhibition '84 Resources Recycling Technology and Energy Saving Instrument Exhibition '84 Osaka Physical Distribution and Materials Handling Exhibition '84 Robot and Automation Equipment Fair	Osaka, Japan	The Nihon Kogyo Shimbun Company, Ltd. 2-4-9, Umeda Kita-ku, Osaka 530
October (tentative)	Institute of Engineers' *Electric Energy* Conference	Perth, Australia	Dr. J. Sullivan Science House 712 Murray Street Perth, W.A. 6000
November 12-15	The Second International Conference on Electrostatic Precipitation	Kyoto, Japan	Professor Senichi Masuda Chairman, The Institute of Electrostatics Japan Sharumu 80 Building, 4 F 4-1-3, Hongo, Bunkyo-ku Tokyo 113
November 22-23	Technology: Past, Present, and Future	Melbourne, Australia	Executive Officer Australian Academy of Technological Sciences Clunies Ross House 191 Royal Parade Parkville, Victoria 3052
November (tentative)	The 7th International Hospital Engineering EXHIBITION (Hospex Japan '84)	Tokyo, Japan	Japan Management Association Kyoritsu Building 3-1-22, Shiba-Koen Minato-ku, Tokyo 105

Date	Title	Site	For information, contact
November (tentative)	'84 Japan Education Materials Exhibition	Undecided, Japan	Japan Association of Manufacturers and Distributors of Educational Materials 1-17-1, Toranomon Minato-ku, Tokyo 105
November (tentative)	Microsystem Show '84	Tokyo, Japan	Japan Microphotography Association Daini Okochi Building 1-9-15, Kajicho Chiyoda-ku, Tokyo 101
November (tentative)	The 19th Exhibition and Conference of New Electrical Insulating Materials	Tokyo, Japan	Japan Electrical Insulation Materials Association Iwao Building 1-16-2, Toranomon Minato-ku, Tokyo 105
November (tentative)	The 23rd Analytical Instruments Show	Tokyo, Japan	Japan Analytical Instruments Manufacturers Taimei Building 3-22, Kanda-Ogawa-cho Chiyoda-ku, Tokyo 100
November (tentative)	'84 Optoelectronic Industry and Technology Exhibition	Tokyo, Japan	The Nihon Kogyo Shimbun Company, Ltd. 1-7-2, Ohtemachi Chiyoda-ku, Tokyo 100
November (tentative)	International Union of Pure and Applied Chemistry, The 7th International Biotechnology Symposium	New Delhi, India	Dr. M. Williams Bank Cout Chambers 2-3 Pound Way Cowley Center Oxford OX4 3YF U.K.
December 3-5	Semicon Japan '84 (Semiconductors)	Tokyo, Japan	Secretariat, Semicon Japan '83 c/o Marcom International Inc. Akasakak-Omotemachi Building, Rm 705 4-8029, Akasaka Minato-ku, Tokyo 107

1984 Continued

Date	Title	Site	For information, contact
Undecided	International Association of Hydrological Science on Groundwater	Undecided, Australia	Dr. J. C. Rodda Water Data Unit Reading Bridge House Reading RG 1 8PS, U.K.
Undecided	The 3rd Asia and Oceania Conference of Nuclear Medicine	Seoul, Korea	Korean Society of Nuclear Medicine 28 Ueong-dong Chongo-ku, Seoul
Undecided	Asian-Australian Association of Animal Production/Animal Science Societies	Seoul, Korea	Department of Animal Science College of Agriculture Seoul National University 103 Seodon-dong Suwon City, (Konggi)
Undecided	International Federation of Society for Electron Microscopy Asian Pacific Electron Microscopy Congress	Singapore	Department of Material Science and Engineering 280 Hearst Mining Building Berkeley, CA 94720 U.S.A.

1985

Date	Title	Site	For information, contact
February 11-14	International Symposium on Characterization and Analysis of Polymers	Melbourne, Australia	Polymer 85 Royal Australian Chemical Institute 191 Royal Parade Parkville, Victoria 3052
February 11-14	Asian Mining '85 (The 2nd Conference)	Manila, Philippines	The Institute of Mining and Metallurgy 44 Portland Place London WIN 4BR U.K.
February (tentative)	The 5th International Congress of Pacific Science Association	Bakguio, Philippines	Dr. Paulo Campos National Research Council of the Philippines Gen Santos Avenue Bicutan, Taguig Metro Manila

Date	Title	Site	For information, contact
March (tentative)	Annual National Conference of the Institution of Engineers, Australia	Melbourne, Australia	LtCol. J.A. McDonald Secretary, Victoria Division Institute of Engineers, Australia National Science Center 191 Royal Parade Parkville, Victoria 3052
May 20-24	The 3rd Conference on Steel Development	Melbourne, Australia	Australian Institute of Steel Construction P.O. Box 434 Milsons Point, N.S.W. 2061
July 14-20	The 6th International Congress for Ultrasound in Medicine and Biology	Sydney, Australia	Dr. R. Jellins P.O. Box R374, Royal Exchange Sydney, N.S.W. 2000
August 12-16	The 6th International Meeting on Ferroelectricity	Kobe, Japan	Professor S. Nomura Physical Electronics Faculty of Engineering Tokyo Institute of Technology Meguro-ku, Tokyo 152
August 18-23	The 8th International Conference on Chemical Education	Tokyo, Japan	The Chemical Socielty of Japan 1-5, Kanda-Surugadai Chiyoda-ku, Tokyo 101
August 19-24	1985 International Symposium on Lepton and Photon Interactions at High Energies	Kyoto, Japan	Research Institute for Fundamental Physics Kyoto University Oiwake-cho, Kita-shirakawa Sakyo-ku, Kyoto 606
August 19-30	The 23rd General Assembly of IASDPEI (International Association of Semismology and Physics of the Earth's Interior)	Tokyo, Japan	Intergroup Corporation Akasaka Yamakatsu Building 8-5-32, Akasaka Minato-ku, Tokyo 107
August 26-30	The 6th International Symposium on Polarization Phenomena in Nuclear Physics	Osaka, Japan	Professor M. Kondo Research Center of Nuclear Physics Osaka University Yamadaoka, Suita Osaka, 530

1985 Continued

Date	Title	Site	For information, contact
August (tentative)	Coastal Engineering Conference	Melbourne, Australia	The Conference Manager Australia The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	International Association Hydraulic Resources Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	The 21st Congress for IAHR (International Association for Hydraulic Research)	Melbourne, Australia	Mr. Robin Vickery Institute of Engineers Australia 11 National Circuit Barton, A.C.T. 2600
September 4-11	The 11th International Teletraffic Congress ITC-11	Kyoto, Japan	ITC-11 Committee Musashino Electrical Communication Laboratory 3-9-11, Midorimachi Musashino, Tokyo 180
September 6-10	1985 Annual Conference of the IIC (International Institute of Communications)	Tokyo, Japan	International Relations Department Japan Broadcasting Corporation 2-2-1, Jinnan Shibuya-ku, Tokyo 150
September 10-13	The 3rd International Cell Culture Congress	Sendai, Japan	Professor S. Yamane Research Institute for Tuberculosis and Cancer Tohoku University 4-1, Seiko-cho Sendai, Miyagi 980
October 15-18	International Rubber Conference	Kyoto, Japan	The Society of Rubber Industry, Japan Tobu Building 1-5-26, Motoakasaka Minato-ku, Tokyo 107

1986 Continued

Date	Title	Site	For information, contact
March 16-21	The 10th International Congress of Prestressed Concrete	New Delhi, India	Mr. C. R. Alimchandani Stup Consultants, Ltd. 1004-5-7, Raheja Chambers 213 Nariman Point Bomblay 420-021
May 11-17	Congress of the International Society of Haematology and the International Society of Blood Transfusions	Sydney, Australia	Dr. I. Cooper, President Haematology Society of Australia Cancer Institute 481 Little Londsdale Street Melbourne, Victoria 3001
July (tentative)	International Institute of Welding Annual Assembly 1986	Tokyo, Japan	Japan Welding Society 10-11, Kanda-Sakumacho Chiyoda-ku, Tokyo 101
August 25-29	The 12th International Congress of the International Association of Sedimentologists	Canberra, Australia	Professor K.A.W. Crook Department of Geology Australian National University P.O. Box 4 Canberra, A.C.T. 2600
August 26-30	International Conference on Martensitic Transformations (ICOMAT-86) in Commemoration of JIM 50th Anniversary	Nara, Japan	ICOMAT-86 The Japan Institute of Metals (JIM) Aoba, Aramaki Sendai 980
August (tentative)	The 7th World Congress on Air Quality	Sydney, Australia	Mr. K. Sullivan Clean Air Society of Australia and New Zealand P.O. Box 191 Eastwood, N.S.W.
September 21-25	The World Congress of Chemical Engineering	Tokyo, Japan	The Society of Chemical Engineers, Japan Japan Kyoritsu Kaikan 4-6-19, Honhinata Bunkyo-ku, Tokyo 112

1986 Continued

Date	Title	Site	For information, contact
September (tentative)	The 8th International Congress of Psychosomatic Obstetrics and Gynecology	Melbourne, Australia	Dr. L. Dennerstein Department of Psychiatry University of Melbourne c/o Royal Melbourne Hospital Parkville, Melbourne 3052
Undecided	International Microbiological Congress	Perth, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601

☆ U.S. GOVERNMENT PRINTING OFFICE : 1984 O - 434-512

NOTICE

The Office of Naval Research Liaison Office, Far East is located at Akasaka Press Center. The ONRFE office is located on the second floor of Bldg #1. Akasaka Press Center and it bears the following mail identification:

Mailing address:	Department of the Navy Office of Naval Research Liaison Office, Far East APO San Francisco 96503
Local Address:	ONR Far East Akasaka Press Center 7-23-17, Roppongi Minato-ku, Tokyo 106
Telephone numbers:	Civilian 03-401-8924 Autovon 229-3236 Telex 222-2511 SANTEL TOKYO

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

BUSINESS REPLY CARD

FIRST CLASS PERMIT NO. 12503 WASHINGTON, D.C.

POSTAGE AND FEES PAID BY DEPARTMENT OF THE NAVY

OFFICE OF NAVAL RESEARCH
LIAISON OFFICE, FAR EAST
APO SAN FRANCISCO 96503

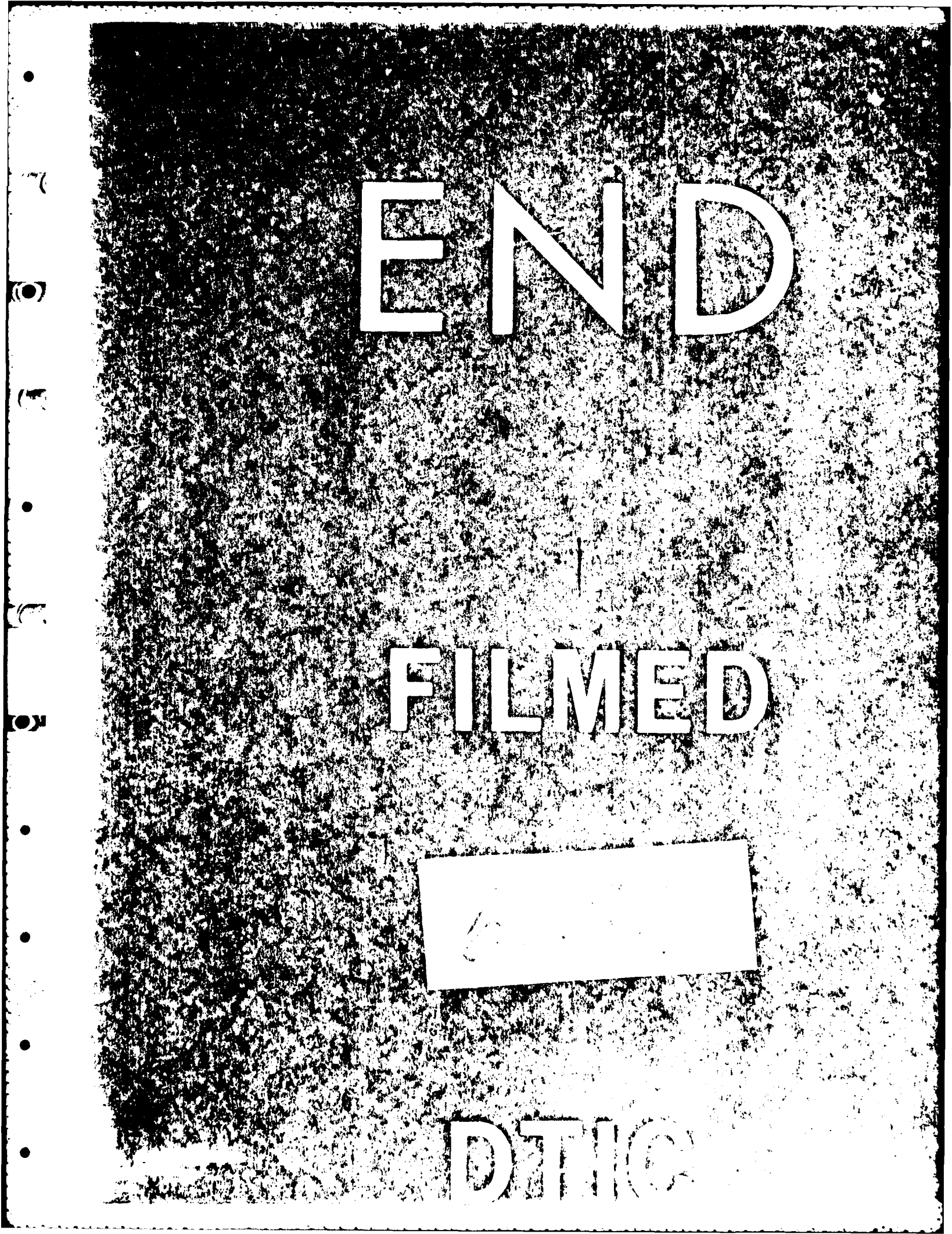
Please continue sending me the ***Scientific Bulletin***

Please make the address change as indicated

Please discontinue sending me the ***Scientific Bulletin***

Old Address

New Address


END
FILMED
DTIC